A vegetation index of biotic integrity for small-order streams in southwest Montana and a floristic quality assessment for western Montana wetlands.

Prepared for:

Montana Department of Environmental Quality
and
U.S. Environmental Protection Agency

By:

W. M. Jones

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August 2005

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Agreement Number:

203097

By:

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This document should be cited as follows:

Jones, W. M. 2005. A vegetation index of biotic integrity for small-order streams in southwestern Montana and a floristic quality assessment for western Montana wetlands. Report to the Montana Department of Environmental Quality and U.S. Environmental Protection Agency, Montana Natural Heritage Program, Helena, Montana. 29 pp. plus appendices.

ABSTRACT

This study evaluated the relationship between grazing-related disturbances and vegetation in first- through third-order montane streams in southwestern Montana. Eight vegetation metrics (relative cover of native graminoids, relative cover of exotic species, relative cover of hydrophytes, cover-weighted floristic quality index, cover-weighted mean bank stability rating, absolute combined cover of seedling and young willows, and willow seedling density) were found to respond to grazing-related disturbances. These metrics were combined into a multimetric index, the vegetation index of biotic integrity (VIBI), which responded strongly to a grazing-associated disturbance gradient. VIBI scoring thresholds were established that differentiated among three condition classes: reference condition, moderately impaired, and severely impaired. The VIBI can be used as an evaluation tool to assess riparian area condition. Coefficients of conservatism, which form the basis for floristic quality assessments, were assigned by an expert panel for plant species likely to occur in western Montana wetlands.

Acknowledgments

This study was funded through a U.S. Environmental Protection Agency wetland protection grant administered by the Montana Department of Environmental Quality. My sincere thanks to all who assisted with this project: Lynda Saul, for her tireless efforts as the linchpin for wetland conservation at Montana DEQ; Randy Apfelbeck, Anna Noson, and Bryce Maxell, for their fruitful involvement with the wetland monitoring and assessment work group; Steve Cooper, for his review of riparian assessment methods; and Greg Kudray and Coburn Currier for editing and formatting the final version of this report. My highest thanks also to Peter Lesica, John Pierce, Steve Shelly, Mary Manning, Steve Cooper, and Scott Mincemoyer for their invaluable help in assigning coefficients of conservation to western Montana wetland plants.

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INTRODUCTION

The list of economic and environmental benefits provided by wetlands and riparian areas is long. These benefits include groundwater recharge, filtration and storage of sediments, nutrients, and pollutants, floodwater storage and attenuation, and unique habitat values (Brinson et al. 1981, Keddy 2000). Consequently, the importance of wetlands and riparian areas is disproportionate to their physical extent on the landscape, especially in semiarid regions such as Montana (Finch and Ruggiero 1993, Patten 1998). Despite their importance to both humans and wildlife, an estimated 25% of Montana's wetlands have been lost in the past 200 years (Dahl 1990). To improve wetland conservation in Montana, the Montana Department of Environmental Quality (DEQ) is developing a comprehensive statewide wetland monitoring and assessment program, of which this present study is a part.

This program will use a three-tiered approach to characterize the condition and extent of wetlands in Montana. DEQ will combine landscape-level remotely sensed data, rapid site-level assessments, and detailed site-level evaluations of biota to evaluate wetland condition and to identify anthropogenic stressors that limit that condition. The purpose of the present study was to identify attributes of the riparian vegetation community of small-order streams that responded predictably to human disturbance. Such attributes could then be used as indicators of wetland condition for detailed site assessments as well as for validating and calibrating rapid assessment methods.

I used a multimetric approach to identify vegetation indicators. Multimetric analysis attempts to determine the status of a wetland or stream reach by directly measuring the condition of one or more of its biotic components (Danielson 2002). This method is based on defining a relatively homogenous study environment and measuring the response of target biota across a human disturbance gradient (Karr and Chu 1999). Ideally, successful metrics should be attributes of the biota that change predictably with increasing human disturbance, are sensitive to a range of biological stresses, discriminate between human-caused perturbations and natural variability, and are easy to measure and interpret (Karr and Chu 1999). Successful metrics can then be combined into a multimetric index that reflects a diverse biotic response to human-related stressors and is an integrative measure of the site's biological condition (Karr and Chu 1999, Teels and Adamus 2002).

Biological assessments can be accurate and cost-effective tools to assess wetland and stream condition and to measure impairment (Karr and Chu 1999). Since biota integrate multiple physical and chemical parameters, directly measuring a biotic community's response to anthropogenic stressors can be the most effective means to evaluate the effect of those stressors on wetland condition and function (Danielson 2002). The utility of using biota to assess wetlands has been demonstrated for numerous taxa, including fish (Karr 1981, Hughes et al. 1998, Mebane et al. 2003), diatoms (Fore and Grafe 2002), benthic and terrestrial macroinvertebrates (Kimberling et al. 2001, Blocksom et al. 2002, Klemm et al. 2003), birds (Bryce et al. 2002), and vegetation (DeKeyser et al. 2003, Mack 2004, Ferreira et al. 2005). This approach has been shown to be effective for perennial and seasonal depressional wetlands and ephemeral and intermittent streams in Montana (Apfelbeck 2001, Jones 2004).

This study was conducted in southwestern Montana where the primary human-related stressors are livestock grazing and agriculture. Livestock grazing can influence numerous physical parameters in riparian systems, including stream channel and bank geomorphology and stability (Kauffman et al. 1983b, Clary 1999, Clary and Kinney 2002), floodplain microchannel sinuosity and drainage density (Flenniken et al. 2001), and soil bulk density, pore space, infiltration, and potential nitrification and mineralization rates (Kauffman and Krueger 1984, Wheeler et al. 2002, Kauffman et al. 2004). By altering these physical parameters as well as by directly removing plant biomass, grazing can significantly affect riparian vegetation. Livestock grazing can decrease belowground biomass (Kauffman et al. 2004), decrease the abundance of woody vegetation, especially willows (Kauffman et al. 1983a, Schulz and Leininger 1990, Clary 1999, Brookshire et al.

2002, Thorne et al. 2005), and increase the abundance of weedy species, such as Kentucky bluegrass (*Poa pratensis* L.) (Schulz and Leininger 1990, Green and Kauffman 1995), possibly by altering competitive interactions with native graminoids (Martin and Chambers 2001). At lower elevations, agricultural land uses and their associated hydrologic modifications become important stressors on riparian systems; however, this study was conducted on smaller order streams that were largely unaffected by agricultural disturbances.

METHODS

Study Area

The study area encompassed portions of Beaverhead and Madison Counties in southwest Montana (Figure 1). This area lies within the Northern Rocky Mountain and Montana Valley and Foothill Prairies Ecoregions (Woods et al. 1999) and is characterized by broad intermontane valleys interspersed with isolated mountain ranges. The geology is a complex mixture of predominately Tertiary and Cretaceous sedimentary rocks with localized intrusions of Tertiary volcanics, Mississippian limestone, Proterozoic quartzite, and Archaean gneiss and schist; Pleistocene glacial deposits are locally abundant at higher elevations (Ruppel et al. 1993, Ruppel 1999, Lonn et al. 2000, Skipp and Janecke 2004). The climate is semiarid and continental. The weather station at Lima, Montana, which is representative of lower elevation sample locations, has recorded mean temperatures ranging from 16.8°F in January to 61.3°F in July and mean precipitation of 12.43 inches annually (Western Regional Climate Center 2005).

Site Selection

Potential sample locations were limited to small-order streams that had been previously evaluated for functional status by the Bureau of Land Management (BLM) and U.S. Forest Service (USFS) using standardized riparian assessments. BLM assessments used the proper functioning condition (PFC) methodology, which combines qualitative evaluations of hydrology, vegetation, and erosion/deposition to evaluate a stream reach (Prichard et al. 1998). USFS assessments evaluated a stream reach's degree of departure from reference condition using quantitative hydro-geomorphological parameters (Bengeyfield 1999). The output of both evaluation methods is to assign a stream reach into one of three condition classes: functioning (or proper functioning condition), functioning at risk, and nonfunctioning. To encompass variability in the degree of human-related disturbance, potential sample reaches were stratified by condition class. Rated reaches were displayed in a geographic information system (ArcGIS 8.3, ESRI, Redlands, California), and 11 functioning, 9 functioning at risk, and 10 nonfunctioning reaches were selected. All 30 stream reaches were sampled from June to August 2004.

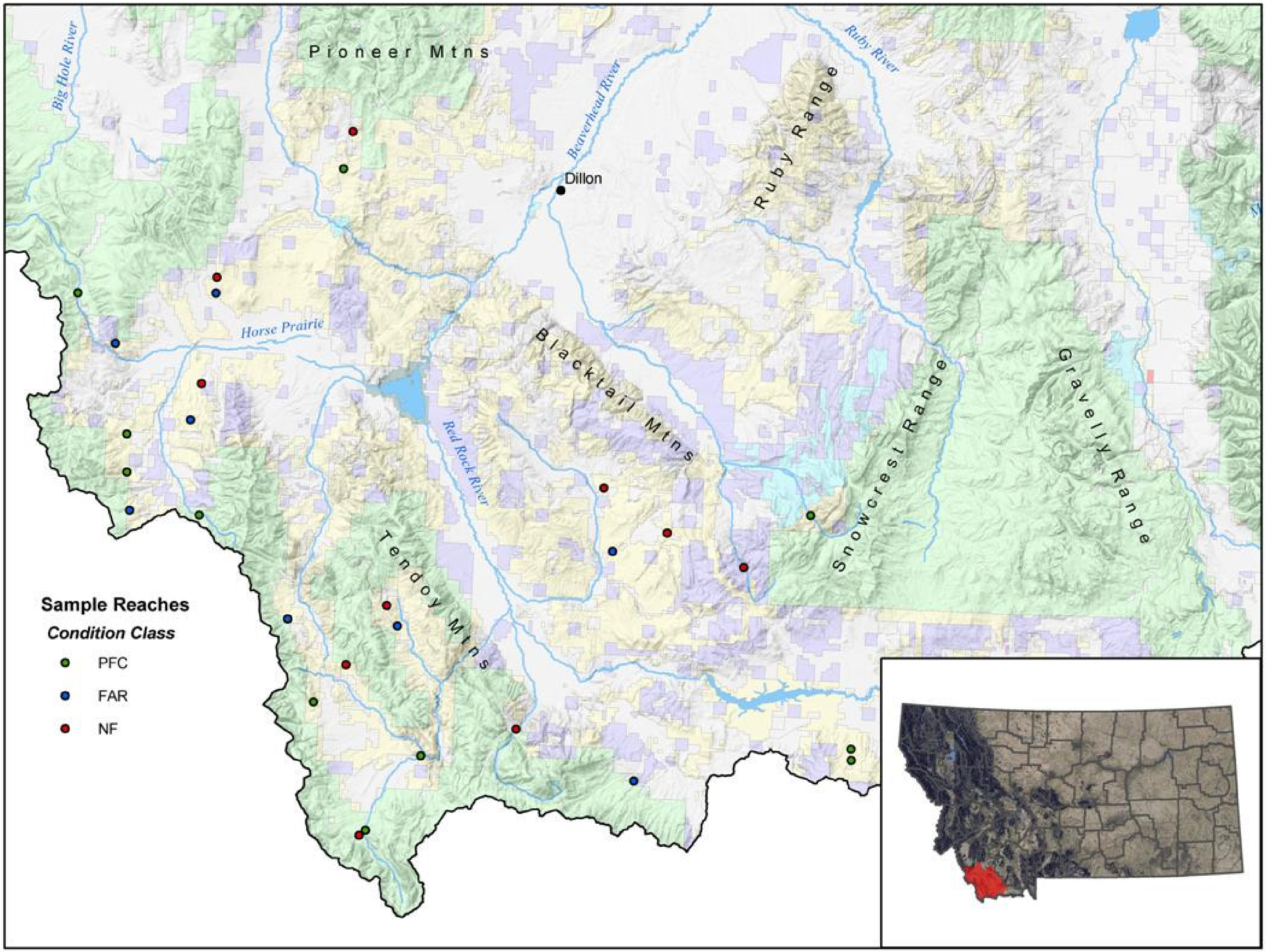
Sample reaches were first- through third-order, low gradient streams ranging in elevation from 6,000 to 7,900 feet above sea level; most reaches would be categorized as "E" type streams under Rosgen's (1996) classification system. All sample reaches were on tributaries to the Beaverhead and Red Rock Rivers on lands managed by the BLM or USFS and supported varying levels of willow cover, predominately Geyer's willow (*Salix geyeriana* Anderss.), Booth's willow (*S. boothii* Dorn), and Drummond's willow (*S. drummondiana* Barratt ex Hook.). Dominant herbaceous species included beaked sedge (*Carex utriculata* Boott), water sedge (*C. aquatilis* Wahlenb.), Baltic rush (*Juncus balticus* Willd.), bluejoint reedgrass (*Calamagrostis canadensis* (Michx.) Beauv.), and Kentucky bluegrass.

Data Collection

The sampling method used to collect species abundance and environmental data was modified from the techniques outlined in Winward (2000) and Coles-Ritchie et al. (2004) and was selected based in part on a review by Cooper (2004). The sample unit was a 100-m stream reach that was subsampled using two types of systematically placed sample frames: 0.1-m^2 (0.2-m × 0.5-m) quadrats and 4-m^2 (1.13-m radius) plots. Sample frames were placed along transects running perpendicular and parallel to the stream channel, such that an area of 100-m × 8-m was sampled along each side of the stream channel (Figure 2).

Streambank sampling was conducted along the greenline, which is defined as the first perennial vegetation that forms a lineal grouping of community types on or near the channel edge and usually occurs at or slightly below bankfull discharge (Winward 2000). Greenline sampling consisted of 20 quadrats placed at 5-m intervals

Figure 1. Locations and functional condition classes of sample reaches. Condition classes are PFC (proper functioning condition), FAR (functioning at risk), and NF (nonfunctioning)



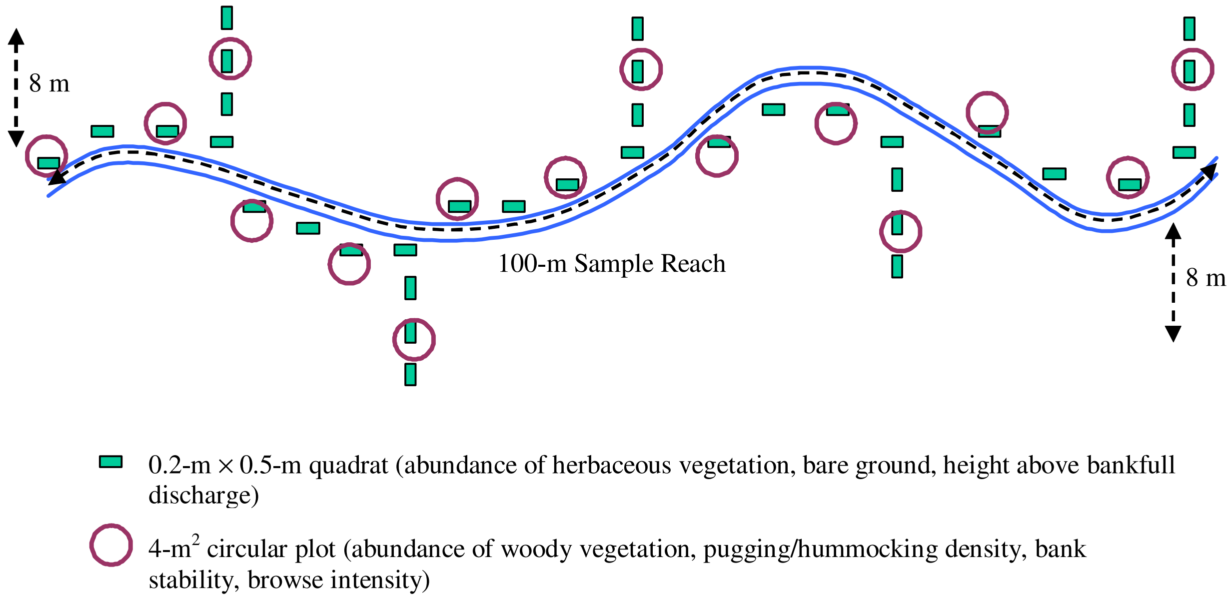


Figure 2. Schematic showing placement of and data collected for subsamples within sample reaches.

and 10 plots placed at 10-m intervals, with groups of four quadrats and one plot being placed on alternating sides of the channel, with the long ends of quadrats placed parallel to the channel. Five transects were also placed perpendicular to the valley slope at an interval of 20 m on alternating sides of the channel. Three quadrats (located 2.5, 5.0, and 7.5 m from the greenline with long ends parallel to the transect) and one plot (located 5.0 m from the greenline) were sampled at each transect.

Species abundances were recorded using the cover estimation method described by Daubenmire (1959). Six cover classes were used to record species abundances: 1 (<5% cover), 2 (5-25% cover), 3 (25-50% cover), 4 (50-75% cover), 5 (75-95% cover), and 6 (>95% cover). Herbaceous vegetation was sampled in quadrats and woody vegetation was sampled in plots. For woody species, both total cover and cover by age class (Table 1) were estimated. Mean height for each age class was estimated to the nearest 0.1 m. The number of woody seedlings present in each plot was also recorded. Species nomenclature follows the PLANTS database (version 3.5), which is the national naming standard used by the federal government (Natural Resources Conservation Service 2004).

Five potential indicators of grazing-related stressors were measured: (1) amount of bare ground, (2) number of hoof shears (pugs) present in each plot, (3) number and mean depth of hummocks present in each plot, (4) bank stability at greenline plots, and (5) browse intensity. Bare ground was measured as the number of quadrat corners that intersected bare mineral soil. Bank stability was evaluated with a 0.15-m wide plot running from the scour line to either twice bankfull height or a flat depositional surface, whichever was lower. A bank was considered unstable if less than 50% of the plot was covered by perennial vegetation ground cover or roots, rocks greater than 0.15-m diameter, or logs greater than 0.1-m

Table 1. Age classes for woody shrub and deciduous tree species.

Age Class[a]	Description: Woody Shrubs	Description: Deciduous Trees
seedling	1 stem	<0.3 m tall
young	2-10 stems	0.3-2 m tall
mature	>10 stems, >½ alive	> 2 m tall, >½ alive
decadent/dead	>10 stems, <½ alive	> 2 m tall, <½ alive

[a] age class determinations were not made for rhizomatous shrub species

diameter, either singly or in combination. Browse intensity was evaluated following the method of Keigley and Frisina (1998). The plant nearest the plot center with a primary stem between 0.5 and 1.5 m high was selected for evaluation; if only taller plants were present, the plant nearest the plot center that had a primary stem with a terminal leader within the browse zone (0.5 to 1.5 m high) that was not mechanically protected was selected. If browsing had killed an entire annual segment on the stem selected, browse intensity was considered heavy; if not, browse intensity was considered light to moderate. This evaluation was performed only if a palatable species with a terminal leader within the browse zone was present (e.g., *Salix* spp., *Cornus sericea* L., *Populus tremuloides* Michx.). Finally, the elevation of greenline quadrats in relation to bankfull discharge was measured to the nearest 0.01 m.

To determine whether the number of subsamples was adequately characterizing vegetation, I examined species area curves for the initial five sites surveyed to see if they met the criterion of less than a 5% increase in the number of species sampled for a 10% increase in sample area (Mueller-Dombois and Ellenberg 1974). All five sites met this threshold by the time 80% of the area had been surveyed; therefore, the sampling intensity was considered adequate.

All data were aggregated to the level of sample reach. Vegetation abundance was calculated by averaging cover class midpoints. Values for all other variables were averaged except for browse intensity and bank stability, which were calculated as frequencies.

Human Disturbance Gradient

Disturbance parameters measured on-site were chosen to be responsive to grazing-related stresses. Two other factors were calculated: allotment stocking rates, which were measured as the number and duration of cow-calf pairs allowed on the allotment (animal unit months (AUMs)), and road density of upstream catchments. The extent of road development was calculated from 2000 TIGER 1:100,000 line files (US Census Bureau 2003), and catchments were delimited with the hydrology modeling extension in ArcGIS using a sink-filled digital elevation model (30-m raster National Elevation Dataset, US Geological Survey 2002). Another commonly used disturbance indicator, percent of catchment in agricultural or other human-modified land cover, was not considered because catchment land cover was comprised almost entirely of native vegetation for all sites. The interpretation of this measurement has also been shown to be problematic because of spatial autocorrelation among land cover classes (King et al. 2005).

To rank sites by their overall disturbance, I calculated a composite disturbance measure using principal components analysis (PCA). PCA identifies linear combinations of the variables that explain the greatest variation in the data. The original dataset can thereby be represented in fewer dimensions with composite variables, termed principal components, than the number of original descriptors. Although PCA was developed for data with multivariate normal distributions, it is robust to departures from normality as long as factors are relatively unskewed (Legendre and Legendre 1998). Disturbance factors were transformed to meet the threshold recommended by McCune and Grace (2002) of $|\text{skewness}| < 1$. The best normalizing power transformation for each variable was estimated using the unconditional Box-Cox maximum likelihood function (Box and Cox 1964), except for the frequency variables bank stability and browse intensity, which were arcsine square root-transformed. Power transformation estimates were calculated using the companion to applied regression (car) package (Fox 2005) for the R statistical environment (Ihaka and Gentleman 1996, R Development Core Team 2005). Data were standardized by ranging such that values varied from [0, 1]. PCA was run on the variance-covariance cross-products matrix of the descriptor variables. The resulting composite axes were determined to be interpretable if they explained more variation in the data than that expected by chance using Frontier's (1976) broken stick model (Jackson 1993).

I compared the derived composite disturbance gradient with the proper functioning condition categories used to initially stratify sites. I used one-way analysis of variance with multiple comparisons to test whether mean composite disturbance scores were different among PFC categories. To compensate for multiple testing, significance values were modified with a Bonferroni correction (Sokal and Rohlf 1995). Assumptions of analysis of variance (normal distribution of residuals and homogenous error variances) were examined graphically and with Levene's test (Levene 1960). Because BLM and USFS methodologies differed somewhat, I tested all sites (n = 30) and sites on BLM land (n = 23). Sites on USFS land were not tested independently due to small sample size (n = 7).

Multimetric Analysis

Vegetation response to the composite disturbance gradient was quantified by developing a multimetric index, termed the vegetation index of biotic integrity (VIBI). VIBI development included several steps. Candidate metrics were screened for their ability to discriminate between least and most disturbed sites and for their overall response to the disturbance gradient. Metrics found to be responsive to human disturbance were tested for redundancy and the most responsive, non-redundant metrics were combined into the VIBI. Metric and VIBI analyses were conducted using R statistical software, except where otherwise noted.

Candidate Metrics

Vegetation attributes that have been considered in other studies fall into several categories: community-based metrics (e.g., species richness and dominance), metrics based on plant functional groups (e.g., annuals, perennials, disturbance-tolerant species), and species-specific metrics (Fennessy et al. 2002). Potential metrics considered in this study were largely derived from the second category. Among those considered were metrics that had been proven to be effective in previous studies (Borth 1998, Helgen and Gernes 2001, DeKeyser et al. 2003, Mack 2004, Jones 2004). Twenty-seven metrics from the following categories were evaluated.

Metrics based on growth form, taxonomy, and nativity – This group comprised the largest number of candidate metrics. Candidate metrics expected to decrease with increasing disturbance were the relative cover of native perennials, native graminoids, and Carices. Those expected to increase with disturbance included the relative cover of exotic species, exotic grasses, and annuals/biennials. Several metrics related to the woody vegetation component were also considered, including density of willow seedlings, cover of willow seedlings, cover of young willows, combined cover of willow seedlings and young willows, total willow cover, and willow age distribution, which was calculated as the combined cover of willow seedlings and young willows divided by total willow cover. Cover values for willow-related metrics were calculated with absolute cover values to emphasize structural differences among sites. All were expected to decrease with human disturbance.

Metrics based on diversity measures – Two diversity measures, the Shannon index and the reciprocal of the Simpson dominance index, were calculated. Both indices are related to and based partly on species richness; however, they also incorporate the equitability of species abundances as well. For example, both indices would rate a plot with one dominant and two incidental species as less diverse than a plot with three equally abundant species. Shannon diversity is calculated as

$$H' = - \sum p_i \log p_i$$

where H´ is the Shannon diversity index and p_i is the relative cover of species *i* within a sample unit. Simpson diversity is calculated as

$$D = 1 / \sum p_i^2$$

where D is the Simpson diversity index. These two measures are similar but vary in their sensitivity to rare species, with Simpson diversity being intermediate between species richness and Shannon diversity in its sensitivity (McCune and Grace 2002). Both indices were expected to decrease with disturbance.

Metrics based on floristic quality – The concept of floristic quality derives from a plant community assessment method developed by

Swink and Wilhelm (1979). Their floristic quality assessment index (FQAI) is based on the perceived affinity of native plant species to particular habitats and their tolerance to disturbance. Within a regional flora, each species' affinity/tolerance is subjectively quantified using an 11-point ordinal standard termed the coefficient of conservatism (*C*) (Table 2). *C*-values are assigned by an expert panel of botanists familiar with the flora in question. Using *C*-values, the floristic quality, and by extension, condition, of different sites can be compared.

The FQAI and derived measures have proven to be highly sensitive indicators of disturbance. The usefulness of the FQAI as a vegetation metric has been demonstrated for prairie potholes and ephemeral streams in the Great Plains (Mushet et al. 2002, DeKeyser et al. 2003, Jones 2004), depressional wetlands in Florida (Cohen et al. 2004), numerous wetland types in Ohio (Lopez and Fennessy 2002, Andreas et al. 2004), and woodlands in southern Ontario (Francis et al. 2000).

Computationally, the FQAI is based on the mean *C*-value of a site's vegetation, which is calculated as:

$$\text{mean } C_j = \sum C_{ij} \,/\, n_j$$

where C_{ij} is the coefficient of conservatism of native species *i* at site *j* and n_j is the number of native species at site *j*. The FQAI score for site *j* is calculated as:

$$\text{FQAI}_j = \sum C_{ij} \,/\, \sqrt{n_j} = (\text{mean } C_j) \times \sqrt{n_j}$$

The square root modifier was proposed by Wilhelm and Ladd (1988) to dampen the effects of species richness on the index. This diminishes disparities between high quality species-poor sites and lower quality species-rich sites. *C*-values used in this study were determined by a panel of expert botanists and are listed in Appendix A.

I applied two modifications to the standard FQAI method similar to those proposed by Cohen et al. (2004). First, I included exotic species in the calculation of the FQAI, which are typically not considered. However, exotic species are an important indicator of site quality and their inclusion in the index seems warranted. The other modification was to weight each species' *C*-value by its relative abundance. Abundance is a more sensitive measure of species response than presence-absence (Rahel 1990), so it is possible that a cover-weighted FQAI may be a better indicator of site condition than the standard formulation. The cover-weighted FQAI (cFQAI) for site *j* was calculated as:

$$\text{cFQAI}_j = \left[\sum (C_{ij} \times a_{ij}) \,/ \sum a_{ij}\right] \times \sqrt{n_j}$$

where a_{ij} is the abundance (measured as cover) of species *i* at site *j* and C_{ij} is the coefficient of conservatism of species *i* at site *j*. Exotic species were included in the calculation of the cover-weighted FQAI. All calculations of mean *C*-value and FQAI were expected to decrease with disturbance.

In addition to the FQAI itself, there are several other potential metrics that can be derived from *C*-values. These include the relative cover of disturbance-tolerant species (species with *C*-values ≤ 2) and disturbance-intolerant species (species with *C*-values ≥ 6).

Metrics based on wetland indicator status – Wetland indicator status is a reflection of a species' affinity for wetland habitats. Species are placed into one of five ordinal categories that represent the

Table 2. Coefficient of conservatism scoring criteria (after Andreas et al. 2004).

C	Criteria
0	Plants with a wide range of ecological tolerances; often opportunistic invaders of natural areas or native taxa that are typically part of a disturbed community.
1-2	Widespread taxa that occur in a variety of communities, including disturbed sites.
3-5	Plants with an intermediate range of ecological tolerances that typify a stable phase of a native community, but that persist under some disturbance.
6-8	Plants with a narrow range of ecological tolerances that typify stable, relatively undisturbed communities.
9-10	Plants with a narrow range of ecological tolerances that exhibit high fidelity to narrow habitat requirements.

likelihood of its occurring in wetlands versus non-wetlands. These categories, scored one through five, are: 1 = obligate upland (species occur almost exclusively in uplands), 2 = facultative upland (species usually occur in non-wetlands), 3 = facultative (species equally likely to occur in wetlands or non-wetlands), 4 = facultative wetland (species usually occur in wetlands), and 5 = obligate wetland (species occur almost exclusively in wetlands). Indicator status values were obtained from the 1988 national list and 1993 Pacific Northwest supplement published by the U.S. Fish and Wildlife Service (Reed 1993). Indicator values for the Pacific Northwest (Region 9) were used. These lists only identified obligate upland species if they occurred in wetlands in another region. Species sampled in this study that did not occur on the lists were coded as obligate upland species.

Three potential metrics were calculated from wetland indicator values: relative cover of hydrophytes (species with an indicator value of obligate or facultative wetland), relative cover of upland species (species with an indicator value of obligate or facultative upland), and the cover-weighted mean wetland indicator value, which is calculated as:

$$cWI_j = \sum (WI_{ij} \times a_{ij}) \;/ \sum a_{ij}$$

where cWI_j is the cover-weighted mean wetland indicator value for site j, WI_{ij} is the wetland indicator value of species i at site j, and a_{ij} is the abundance of species i at site j. Relative cover of hydrophytes and cWI were expected to decline with increasing disturbance, while the relative cover of upland-associated species was expected to increase.

Metrics based on bank stability rating – The last category of metrics were derived from the ability of species to stabilize streambanks either with deep binding root masses or other mechanical means (e.g., Abernathy and Rutherfurd 2001, Simon and Collison 2002). Ordinal stability ratings were assigned to species based on similar categorizations in Crowe and Clausnitzer (1997, Appendix D), Hansen et al. (1995, Appendix A-7), and the author's judgment. Ratings were scored as 1 = poor, 2 = fair, 3 = good, and 4 = excellent. Two potential metrics were calculated: relative cover of stabilizing species (species with stability ratings of good or excellent) and the cover-weighted mean bank stability rating, which was calculated as:

$$cSR_j = \sum (SR_{ij} \times a_{ij}) \;/ \sum a_{ij}$$

where cSR_j is the cover-weighted mean vegetation stability rating for site j, SR_{ij} is the stability rating of species i at site j, and a_{ij} is the abundance of species i at site j. Only data from greenline transects were used to calculate bank stability metrics. Both metrics were expected to decrease with disturbance. Stability ratings for species are listed in Appendix B.

Metric Evaluation and Selection

A three-step selection process was used to evaluate candidate metrics for inclusion in the VIBI, similar to Blocksom et al. (2002). The three criteria were the ability of metrics to discriminate between least and most disturbed sites, the overall relationship between metrics and the composite disturbance gradient, and redundancy among metrics. To test discriminatory power, I identified least disturbed sites (disturbance score <25th percentile of disturbance index) and most disturbed sites (disturbance score >75th percentile of disturbance index). Percentiles were calculated in the R statistical package using the method recommended by Hyndman and Fan (1996). Box plots were used to examine metric distributions. Metrics were scored based on their ability to differentiate between the two disturbance categories using the methodology described by Barbour et al. (1996). Metrics that had no overlap of interquartile range (middle 50% of observations) were scored 3, those that had no overlap of median and interquartile range were scored 2, those that had an overlap of one median and interquartile range were scored 1, and those where both medians overlapped with interquartile ranges were scored 0. Candidate metrics with scores of 2 or 3 were retained for further evaluation.

The overall relationship between metrics and disturbance was evaluated by examining scatterplots and Spearman rank correlation coefficients (r_s). Metrics with either $|r_s| > 0.5$ or a strong curvilinear relationship were retained.

Finally, to ensure that metrics would not be providing redundant information to the VIBI, I examined correlations among the remaining candidate metrics. I used the high threshold recommended by the U.S. Environmental Protection Agency ($|r_s| > 0.9$) to determine redundancy (USEPA 1998). Where two or more metrics were found to be redundant, the one with the greatest discriminatory power and greatest response to disturbance was retained.

Metric Scoring

Metrics are usually scored by assigning value ranges to discrete categories depending on their deviation from an expected reference condition (Karr 1981, Wilcox et al. 2002, DeKeyser et al. 2003, Mack 2004). A commonly used scheme is to assign reference condition sites a score of 5, sites that deviate somewhat from reference condition a score of 3, and sites that strongly deviate from reference condition a score of 1 (Karr and Chu 1999). However, others have suggested that scoring metrics along a continuous scale would be more accurate, less variable, and easier to interpret (Minns et al. 1994, Hughes et al. 1998, McCormick et al. 2001, Mebane et al. 2003). Blocksom (2003) found that continuous scoring improved the overall performance of the multimetric index when compared to discrete scoring methods.

Before scoring metrics I first identified the 95th percentile value of each metric (5th percentile value of metrics that increased in response to disturbance), which I used as the best expected value to reduce the effect of outliers (Barbour et al. 1999). Metrics were scored by linear interpolation. Scores of metrics that decreased in response to disturbance were calculated by dividing the observed value by the 95th percentile value; scores of metrics that increased in response to disturbance were calculated by dividing the difference between the maximum and observed value by the difference between the maximum and 5th percentile value. Percentile values were rounded to the nearest percent for metrics measured in percent cover, to the nearest hundredth for seedling density, and to the nearest tenth for cover-weighted averages. Resulting scores were truncated to range between [0, 1]. Metrics with a curvilinear response to the disturbance gradient were log-transformed prior to scoring to improve linearity in their response to the composite disturbance gradient. Log transformations were chosen based on the Box-Cox power transformation constrained by the disturbance gradient. The Box-Cox parameter was estimated using the MASS package (Venables and Ripley 2002) for R software.

VIBI Scoring and Evaluation

VIBI scores were calculated by averaging scores of selected metrics and multiplying by 100. The VIBI therefore ranged from 0 to 100 regardless of the number of metrics found to be interpretable. The strength of the relationship between the VIBI and the composite disturbance gradient was evaluated using ordinary least squares regression. Assumptions of linear regression (normal distribution, constant variance, and independence of errors) were examined graphically.

One application of the VIBI is to use it as a validation tool to assess the accuracy of rapid assessments. The output of the rapid assessment is an ordinal rating of wetland condition. To provide a congruent VIBI scoring system, I wanted to determine how many condition classes the VIBI could accurately distinguish and to identify scoring thresholds for those categories. To determine the number of condition classes, I first categorized the composite disturbance gradient into k = 3 to 5 groups. I used the 25th and 75th percentiles to partition the disturbance gradient into three disturbance categories, the 25th, 50th, and 75th percentiles to partition it into four disturbance categories, and the 20th, 40th, 60th, and 80th percentiles to partition it into five disturbance categories. One-way analysis of variance with multiple comparisons was used to test whether mean VIBI scores were different among disturbance categories and whether means for individual disturbance categories were different from one another. Significance values were modified with a Bonferroni correction. Only partitions where all VIBI means were different were considered useful. Analysis of variance assumptions were evaluated as described previously.

VIBI scoring thresholds that best predicted membership to disturbance classes was identified using classification trees. Given a dataset with predefined groups, classification trees recursively partition that dataset into increasingly homogenous subsets with regard to the groups (Breiman et al. 1984, Urban 2002). At each partition, the tree algorithm identifies the scoring threshold for the predictor variable that best predicts group membership. This process continues until a minimum node size is met. Classification tree analysis was implemented using Therneau and Atkinson's (2005) rpart package for R software. Minimum node size to be split was set at 15. Tree overfitting was controlled with an iterative 10-fold cross-validation procedure. Classification accuracy was evaluated by comparing predicted to actual group membership.

Indicator species analysis was used to identify species that were strongly associated with VIBI condition categories. Indicator species analysis examines the frequency of occurrence and abundance of species within groups and assigns a group indicator value based on the specificity and fidelity of a species to that group (Dufrêne and Legendre 1997). Group indicator values range from 0 (no indication of group membership) to 100 (perfect indication). The strength of association was tested using a Monte Carlo randomization procedure with 10,000 iterations. Species with indicator values >25 and *P*-values <0.1 were reported. Indicator species analysis was performed using PC-ORD (McCune and Mefford 1999).

Whole Community Analysis

The vegetation metrics previously described represent the aggregated response of plant species with similar taxonomic or functional attributes to human disturbance. As a complement to the multimetric analysis, I also examined the simultaneous response of the entire vegetation community to human disturbance. Relationships among sample reaches in regard to the entire vegetation community were explored with nonmetric multidimensional scaling (NMS, Kruskal 1964, Mather 1976). NMS is an indirect ordination technique that attempts to describe underlying patterns of species composition by graphically summarizing complex relationships and displaying them in a few, usually two or three, dimensions (McCune and Grace 2002). NMS iteratively seeks the best representation of sample units in reduced space using an objective function, termed stress, that measures differences between ranked distances in the original multidimensional space and the reduced ordination space (Legendre and Legendre 1998). The global form of NMS was calculated using the Kulczynski distance measure (equivalent to the relativized form of the Bray-Curtis (= Steinhaus) distance measure). Dimensionality of the ordination was determined with PC-ORD's autopilot mode using 40 runs with real data and 50 runs with randomized data. Dimensionality was chosen by selecting the highest number of dimensions that appreciably reduced stress and where the final stress was significantly lower than that for randomized data (McCune and Mefford 1999). The instability criterion to be achieved was set at 0.00001 after 500 iterations or within 50 continuous iterations. To reduce beta diversity (compositional heterogeneity among sample units (Whittaker 1972)) and improve the interpretability of results, species occurring in fewer than 5% of sample units were removed from the analysis.

The Mantel test (Mantel 1967) was used to evaluate whether the whole vegetation community was significantly correlated with the composite disturbance gradient. The Mantel test calculates linear or rank correlations between distance matrices derived from the original data tables. For this test, the Kulczynski and Euclidean distance measures were used to calculate distances for the species composition and disturbance matrices, respectively. The standardized Mantel statistic, $r_{M,}$ which provides a measure of the strength of the correlation between the two matrices, was calculated on ranked distances and is equivalent to Spearman's rank correlation coefficient. Significance was tested by permutation with 10,000 iterations using the community ecology (vegan) package (Oksanen et al. 2005) for R software.

Spatial Autocorrelation Analysis

Spatial autocorrelation can be broadly defined as a significant positive or negative correlation of the values of a variable as a function of distance (i.e., samples of a variable that are closer together in space having more similar values than those further away would be an example of positive spatial autocorrelation). Spatial autocorrelation is a very general phenomenon that operates at multiple scales for most ecological and environmental variables, and it is an important functional property of ecosystems (Legendre 1993). Autocorrelated data are problematic, however, because they violate an important assumption of many statistical tests, that observations of variables are independent from one another. The presence of positive autocorrelation between closely spaced observations distorts many tests and increases the likelihood of erroneous findings of statistical significance (Legendre and Legendre 1998). This has been observed for tests of normality (Dutilleul and Legendre 1992), analysis of variance (Legendre et al. 1990), and linear regression (Cliff and Ord 1981). However, Legendre et al. (2002) have shown that tests of significance for correlation and regression coefficients were valid unless both the response and predictor variables were spatially autocorrelated.

I used two approaches to test for the presence of spatial autocorrelation. For environmental variables and derived vegetation variables (metrics), spatial autocorrelation was evaluated for each factor independently. Two statistics, Moran's *I* and Geary's *c*, were calculated using Rookcase software (Sawada 1999). These statistics are sensitive to departures from normality, and data were transformed as needed as previously described. Distances between sites were calculated from site coordinates projected in Euclidean space (Montana State Plane, 1983 North American Datum). Inter-site distances were divided into 10 classes and values for *I* and *c* were calculated for each class. The number of distance classes was chosen using Sturge's rule based on 30 samples and 435 pairwise comparisons (number of classes = $1 + 3.3\log_{10}(435) = 9.7$) (Legendre and Legendre 1998). The significance of correlation coefficients was tested using a Monte Carlo randomization procedure with 10,000 iterations. Because the significance of coefficients was tested multiple times (once for each distance class), significance levels were adjusted with a Bonferroni correction. As the study area was relatively environmentally homogenous, second-order stationarity was assumed.

Spatial structure of the entire vegetation community was examined with a multivariate Mantel correlogram. Using the method described by Legendre and Legendre (1998), based on Oden and Sokal (1986), standardized Mantel statistics were calculated for a multivariate species distance matrix (calculated with the Kulczynski distance measure) and model matrix based on inter-site distances. Mantel statistics were calculated for each distance class and significance values were calculated by Monte Carlo permutations with 9,999 iterations using PC-ORD. Because of multiple testing, significance values were corrected with a Bonferroni procedure.

Results

Human Disturbance Gradient

The composite disturbance gradient was calculated from a PCA of four variables: AUM, amount bare ground, bank stability, and browse intensity. The first principal component explained 58.8% of the variation in the data. It was considered interpretable as it explained more variation in the data than expected by chance. Subsequent principal components did not meet this criterion. The component was rescaled so that it ranged between [0, 1], with the least disturbed site scoring 0 and the most disturbed site scoring 1, and was used to represent a composite human disturbance gradient for metric development. Table 3 shows the contributions of the original variables to the composite disturbance index.

A PCA including road density was also run. It was rejected in favor of the four variable model because the addition of road density weakened the interpretability of the first principal component (component explained 46.9% of the variation, not much more than that expected by chance) while road density explained less than 1% of the variation of the component.

Table 3. Contribution of individual disturbance factors to a composite disturbance measure extracted by principal components analysis.

Factor	Variance Explained (R^2)
AUM	0.223
bare ground	0.346
bank stability	0.252
browse intensity	0.179

Measures of pug and hummock density were not included in the composite human disturbance gradient. The relationship of these measures to grazing intensity appeared to be confounded by physical characteristics of the site, as the extent of pugging and hummocking is controlled to some extent by soil texture and geomorphology. Sites with finer texture soils and depositional surfaces at lower elevations relative to bankfull discharge will likely be more susceptible to pugging and hummocking development. Although the relationship between pugging and hummocking and soil texture is only anecdotal for this dataset, there was a significant correlation between the elevation of the greenline relative to bankfull discharge and hummock density ($r_s = -0.42$, $P = 0.02$) and mean hummock depth ($r_s = -0.42$, $P = 0.02$) and a weak correlation between greenline elevation and pug density ($r_s = -0.34$, $P = 0.07$).

The composite disturbance gradient and PFC categories were positively associated, both for all sites ($F_{2, 27} = 9.81$, $P = 0.0006$) and BLM sites ($F_{2, 20} = 11.81$, $P = 0.0004$). However, while composite disturbance scores were significantly different between functioning and functioning at risk categories (all sites, $P = 0.003$; BLM sites, $P = 0.001$) and between functioning and nonfunctioning categories (all sites, $P = 0.002$; BLM sites, $P = 0.001$), composite disturbance scores were not different between functioning at risk and nonfunctioning categories (all sites, $P = 0.81$; BLM sites, $P = 0.93$) (Figure 3, results from all sites analysis shown).

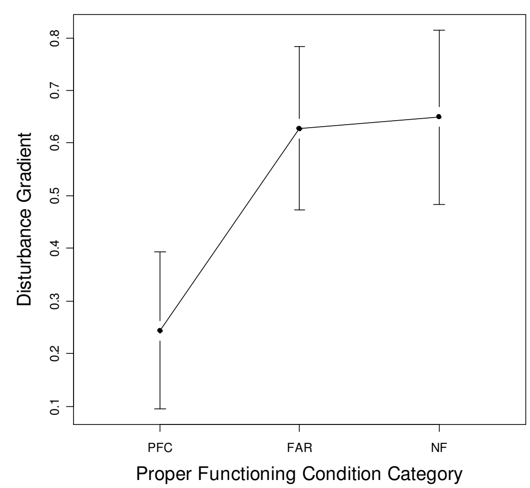


Figure 3. Graphical representation of the relationship between PFC categories and the composite disturbance gradient. Points are disturbance gradient means within PFC categories; error bars are 95% confidence intervals. PFC categories are proper functioning condition (PFC), functioning at risk (FAR), and nonfunctioning (NF); higher disturbance gradient scores reflect greater disturbance.

Metrics

Of the 27 candidate metrics evaluated, eight were selected for inclusion in the VIBI. Five metrics were removed for failing to discriminate between least and most disturbed sites, five were eliminated due to a poor relationship with the disturbance gradient, and nine were removed because of redundancies with the selected metrics. Groups of redundant metrics included relative cover of native perennials, exotic species, exotic grasses, and intolerant species; willow seedling density and cover of willow seedlings; cover of young willows and combined cover of young and seedling willows; cover-weighted mean *C*-values and cover-weighted FQAI; relative cover of hydrophytes and cover-weighted mean wetland indicator status; and relative cover of bank stabilizing species and cover-weighted mean bank stability rating. Table 4 shows the correlation of candidate metrics with the composite disturbance gradient, whether each metric was selected for inclusion in the VIBI or not, and the reason for removal of metrics not selected.

Selected metrics were the relative cover of native graminoids, relative cover of exotic species, density of willow seedlings, combined cover of willow seedlings and young willows, cover-weighted FQAI, relative cover of hydrophytes, and cover-weighted mean bank stability rating.

Table 4. Candidate metrics considered for inclusion in the VIBI, whether metrics were included and reason for removal if not selected, and metric response to composite disturbance gradient as measured by the Spearman rank correlation coefficient. Poor discriminatory power refers to the lack of difference in metric values between least and most disturbed sites; poor correlation with disturbance gradient refers to metrics with weak or no correlations with the composite disturbance gradient (r_s <0.5 for metrics with linear association; graphical evaluation for metrics with curvilinear association).

Metric	Selected/reason for removal	Response to disturbance gradient (r_s)
relative cover of native perennials	redundant	-0.69
relative cover of native graminoids	selected	-0.59
relative cover of sedges	poor correlation with disturbance gradient	-0.48
relative cover of exotic species	selected	0.70
relative cover of exotic grasses	redundant	0.56
relative cover of annuals/biennials	selected	0.45
willow seedling density	selected	-0.50
absolute cover of willow seedlings	redundant	-0.52
absolute cover of young willows	redundant	-0.39
combined absolute cover of young and seedling willows	selected	-0.44
absolute cover of willows	poor discriminatory power	-0.13
willow age distribution	poor correlation with disturbance gradient	-0.42
Shannon diversity index	poor discriminatory power	-0.15
Simpson diversity index	poor discriminatory power	-0.18
mean *C*-value	poor discriminatory power	-0.08
FQAI	poor correlation with disturbance gradient	-0.34
mean *C*-value (including exotic species)	poor discriminatory power	-0.27
FQAI (including exotic species)	poor correlation with disturbance gradient	-0.38
mean cover-weighted *C*-value	redundant	-0.59
cover-weighted FQAI		-0.59
relative cover of disturbance tolerant species (C ≤ 2)	redundant	0.65
relative cover of disturbance intolerant species (C ≥ 6)	poor correlation with disturbance gradient	-0.39
relative cover of hydrophytes	selected	-0.60
relative cover of upland species	redundant	0.32
cover-weighted mean wetland indicator status	redundant	-0.58
relative cover of bank stabilizing species	redundant	-0.54
cover-weighted mean bank stability rating	selected	-0.57

Formulas used to compute selected metrics and metric values for the 95th or 5th percentiles are shown in Table 5; Figure 4 (facing pages) displays the discriminatory power and relationships of selected metrics to the composite disturbance gradient.

VIBI

The VIBI showed a highly significant response to the composite disturbance gradient (VIBI = 85.08 – 47.14 × [disturbance score], $F_{1, 28} = 34.32$, $R^2 = 0.55$, $P = 0.000003$; Figure 5). However,

Table 5. Formulas used to score metrics. Maximum and percentile values are rounded to nearest percent (relative cover metrics), hundredth (seedling density), or tenth (cover-weighted means). $q_{0.95}$ and $q_{0.05}$ refer to the 95th and 5th percentiles, respectively.

	Value			
Metric	Maximum	95th percentile	5th percentile	Formula
relative cover of native graminoids		50		%ngram / $q_{0.95}$
relative cover of exotic species	55		5	(max - %exotic) / (max - $q_{0.05}$)
relative cover of annuals/biennials[a]	18		0	(max - %ann) / (max - $q_{0.05}$)
willow seedling density (# / m^2)[b]		0.58		sden / $q_{0.95}$
cover seedling+young willows[c]		9		%yngSalix / $q_{0.95}$
cover-weighted FQAI		30.5		cFQAI / $q_{0.95}$
relative cover of hydrophytes		80		%hydro / $q_{0.95}$
cover-weighted mean bank stability rating		3.4		bank / $q_{0.95}$

[a] values were transformed by $\log_{10}(\%ann + 1)$ prior to scoring
[b] values were transformed by $\log_{10}(sden + 0.01) + 2$ prior to scoring
[c] values were transformed by $\log_{10}(\%yngSalix + 0.1) + 1$ prior to scoring

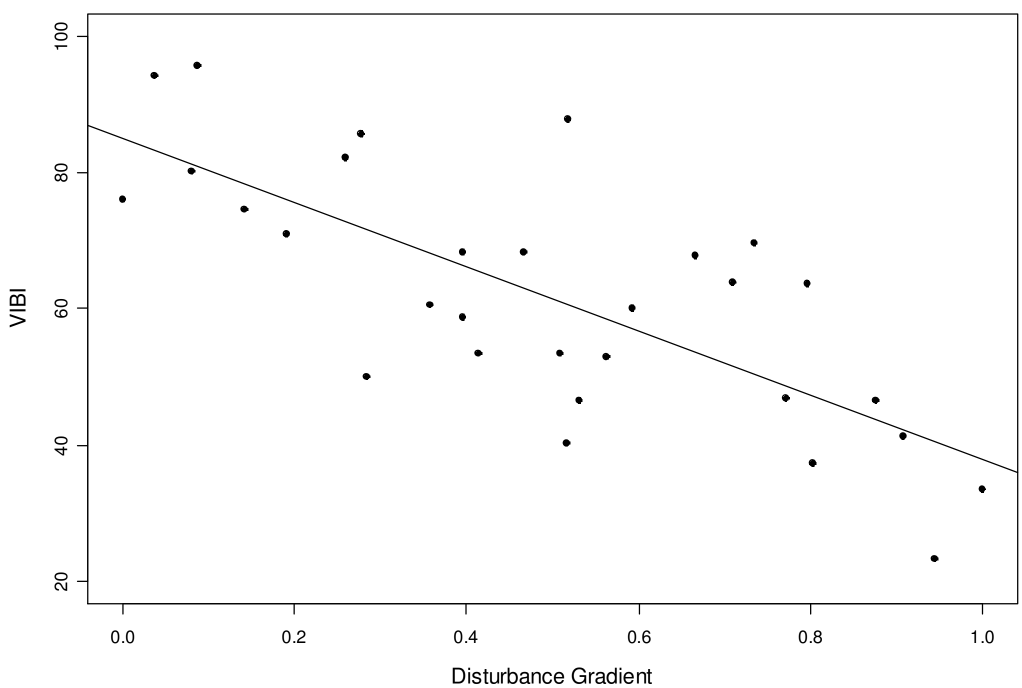


Figure 5. Scatterplot showing the relationship between the vegetation index of biotic integrity (VIBI) and a composite human disturbance gradient. Disturbance gradient ranges from 0 (least disturbed) to 1 (most disturbed); VIBI ranges from 100 (highest condition) to 0 (lowest condition). Solid line represents the fitted linear relationship when the VIBI is regressed on the disturbance gradient using ordinary least squares.

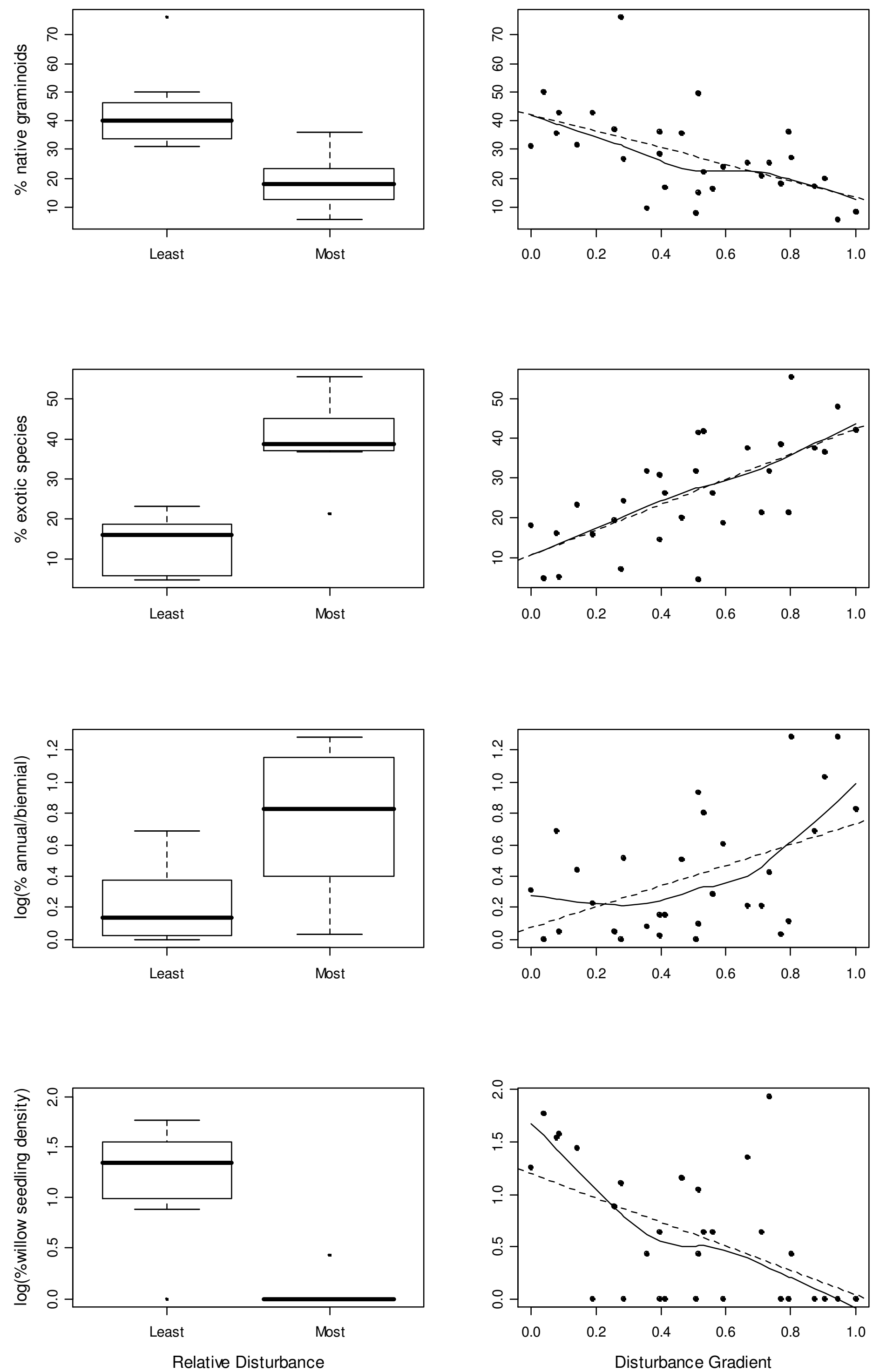


Figure 4. Discriminatory power of selected metrics and their relationship with a composite human disturbance gradient. Boxplots compare vegetation attribute values between least and most disturbed sites. Boxes show the range of the middle 50% each metric's distribution; thick lines within boxes represent median values. Vertical lines (whiskers) show metric values within 1.5 quartiles of the box; dots show more extreme values. Dashed lines in scatterplots show the fitted linear relationship when attributes are regressed on disturbance using ordinary least squares; solid lines show a locally weighted nonparametric smoother.

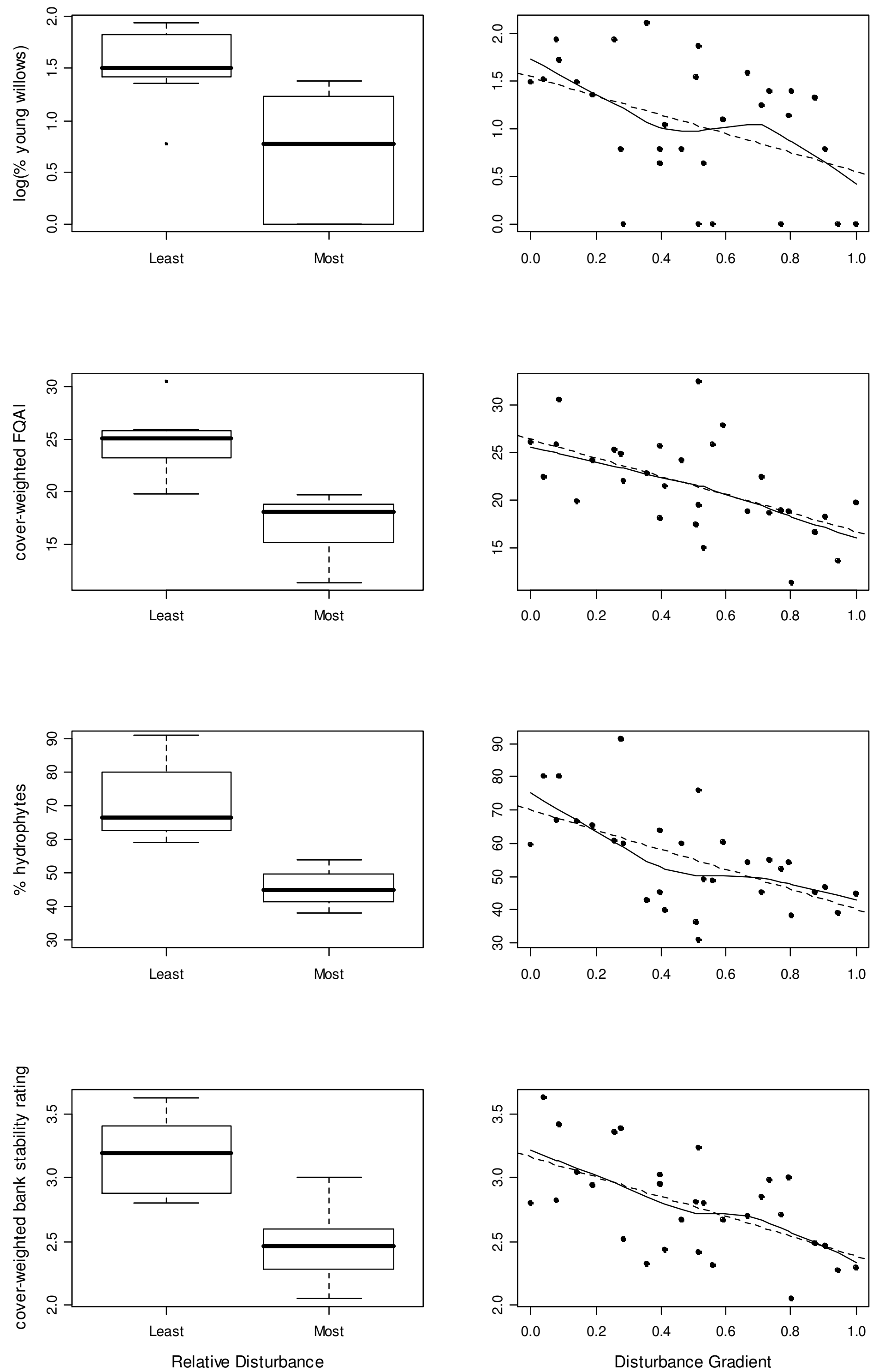


Figure 4. (Continued)

Table 6. Accuracy assessment of VIBI scoring thresholds with regard to disturbance classes.

	Predicted disturbance class			
Actual class	Least disturbed	Moderately disturbed	Most disturbed	Actual total
Least disturbed	8	0	0	8
Moderately disturbed	1	12	2	15
Most disturbed	0	1	6	7
Predicted total	9	13	8	30
Overall accuracy	87%			

VIBI scores could reliably only differentiate three condition classes ($F_{2, 27} = 23.09$, $P = 0.0000001$, all pairwise comparisons significant at the 0.001 level after Bonferroni correction). Overall, the VIBI was relatively robust in its ability to differentiate between these classes (Table 6). While analyses of variance of the four- and five-category partitions of the composite disturbance gradient were significant, VIBI means were not strongly differentiated among all disturbance categories. Sites with VIBI scores above 70 were considered to be reference condition (Figure 6), sites with scores from 48 to 70 were considered to be moderately impaired (Figure 7), and sites with scores below 48 were considered to be severely impaired (Figure 8). Figure 9 graphically displays VIBI scoring thresholds, condition classes, and misclassified cases. Species indicative of each condition class are shown in Table 7.

Figure 7. Moderately impaired site; channel shows evidence of past incisement but is stable.

Figure 8. Severely impaired site; note incised and unstable banks.

Figure 6. Reference condition site.

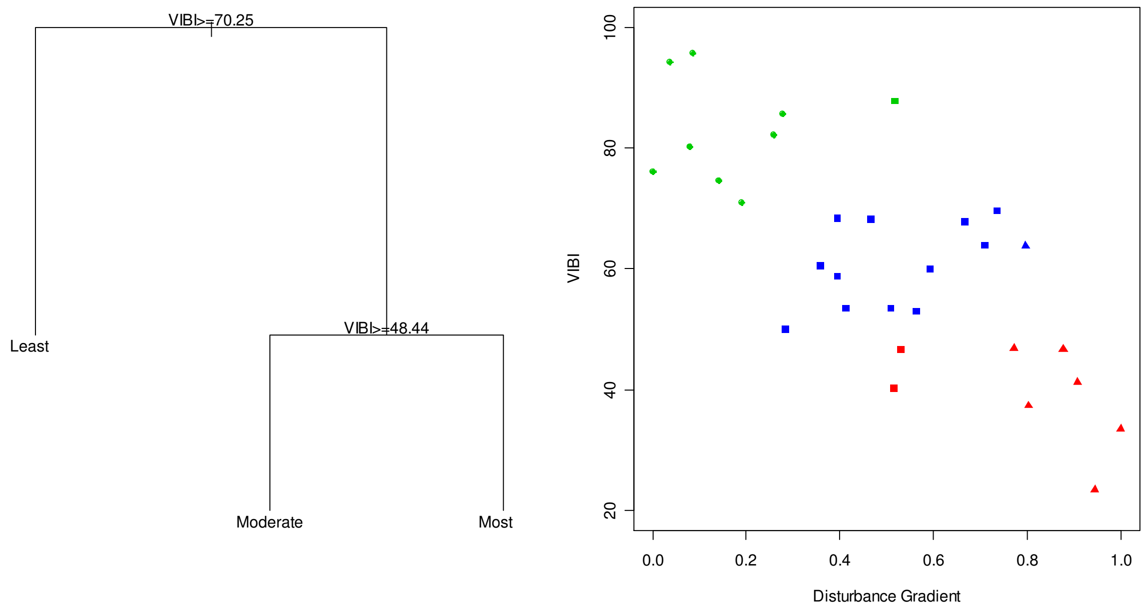


Figure 9. (A) Tree diagram showing VIBI scoring thresholds associated with disturbance categories. Least = least disturbed, Moderate = moderately disturbed, Most = most disturbed. (B) Scatterplot of the composite disturbance gradient and VIBI. Symbols represent disturbance categories: ● = least disturbed sites, ■ = moderately disturbed sites, ▲= most disturbed sites. Colors represent VIBI classes: green = reference condition, blue = moderately impaired, red = severely impaired.

Table 7. Species indicative of reference, moderately disturbed, and severely disturbed sites. Indicator value represents the strength of indication (0 = no indication, 100 = perfect indication). P-values were calculated with a Monte Carlo permutation test. Species with indicator values >25 and P <0.1 are reported.

Scientific Name	Common Name	Condition Class	Indicator Value	*P*-value
Agrostis scabra	rough bentgrass	reference	39.4	0.049
Carex aquatilis	water sedge	reference	58.5	0.022
Carex utriculata	beaked sedge	reference	50.3	0.044
Galium trifidum	threepetal bedstraw	reference	46.6	0.073
Juncus ensifolius	swordleaf rush	reference	67.4	0.004
Salix drummondiana	Drummond's willow	reference	50.6	0.008
Iris missouriensis	Rocky Mountain iris	moderately impaired	37.7	0.058
Maianthemum stellatum	starry false lily of the valley	moderately impaired	47.1	0.057
Mertensia ciliata	tall fringed bluebells	moderately impaired	39.0	0.063
Muhlenbergia richardsonis	mat muhly	moderately impaired	37.5	0.088
Potentilla gracilis	slender cinquefoil	moderately impaired	61.3	0.012
Pyrola asarifolia	liverleaf wintergreen	moderately impaired	34.5	0.061
Trifolium longipes	longstalk clover	moderately impaired	54.0	0.047
Carex nebrascensis	Nebraska sedge	severely impaired	29.4	0.087
Cirsium vulgare	bull thistle	severely impaired	37.5	0.017
Poa pratensis	Kentucky bluegrass	severely impaired	46.8	0.011
Ranunculus abortivus	littleleaf buttercup	severely impaired	50.5	0.036
Rosa woodsii	Woods' rose	severely impaired	64.5	0.003
Trifolium repens	white clover	severely impaired	68.4	0.001
Triglochin palustre	marsh arrowgrass	severely impaired	28.7	0.089

Whole Community

Relationships among sample units are graphically displayed in Figure 10, which shows the results from the NMS ordination (three-dimensional solution, stress = 12.56, instability <0.00001, 83 iterations). The ordination diagram shows that vegetation is differentiated along the composite disturbance gradient, as evidenced by the relatively distinct groupings of VIBI condition classes. The vegetation community was significantly correlated with the disturbance gradient ($r_M = 0.15$, $P = 0.02$).

Spatial Autocorrelation

No significant spatial autocorrelation was observed for either environmental or vegetation-derived variables at any distance class after Bonferroni corrections. Autocorrelation in the vegetation community trended from positive to negative over increasing distances; however, these results were nonsignificant after a Bonferroni correction.

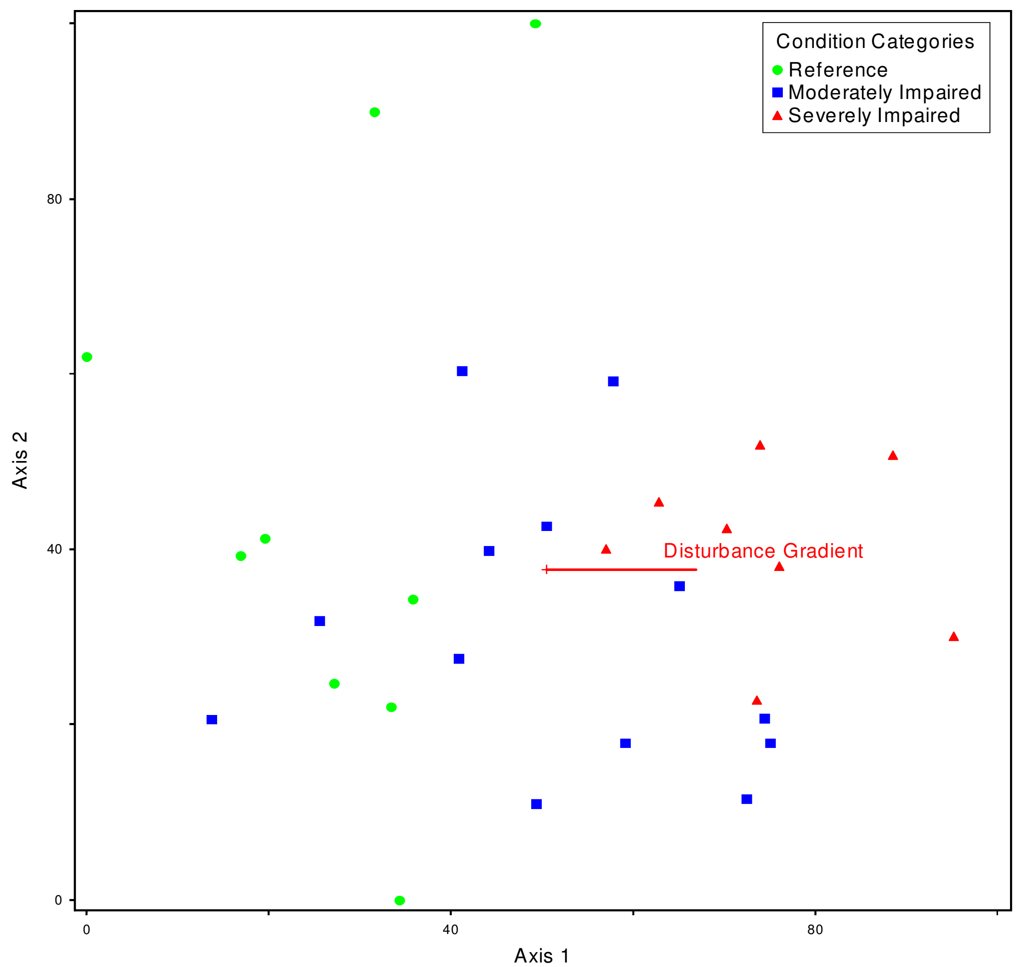


Figure 10. Graphical representation of the NMS ordination of sample reaches. Points represent aggregated species cover and composition data for each sample reach. Distance between points is proportional to dissimilarity between samples (i.e., samples with similar species composition are plotted closer together). Axis 1, which corresponds to the composite disturbance gradient, represents 20% of the variation in the data; Axis 2 accounts for 47% (total variation explained = 67%). The vector represents the strength of the relationship between Axis 1 and the composite disturbance gradient ($R^2 = 0.31$). Condition categories refer to VIBI condition classes.

Discussion

The goal of this study was to find attributes of the riparian vegetation community that responded predictably to human disturbance and could be used to assess site condition. Eight such attributes were identified and combined into a vegetation index of biotic integrity. Overall, this multimetric index demonstrated a robust response to grazing-related stressors, and VIBI scores could be used to classify a site into one of three disturbance categories with relatively high accuracy. Within the reference domain considered – small-order montane streams able to support woody vegetation – the VIBI appears to be a good indicator of site condition. This is consistent with other multimetric vegetation studies that have found plants to be good indicators of wetland and riparian condition (DeKeyser et al. 2003, Mack 2004, Jones 2004, Ferreira et al. 2005).

Both a strength and complication of using vegetation as an indicator of site condition is the large number of species often involved. For example, 178 species of vascular plants were sampled in the course of this study, and the mean richness was 43 ± 7 species per site. A strength of the multimetric approach is that species are grouped by the expected similarity of their response to disturbance or stress. This makes use of redundancies in species' responses within groups and can thereby reduce the noise often generated when the response of all species is considered simultaneously. This study made use of species groups based on functionality, taxonomy, and nativity. The utility of vegetation classifications based on common attributes, adaptations, or responses of species to environmental factors, has long been recognized (Raunkiaer 1934, Grime 1977, Grime 1988, Lavorel and Garnier 2002, Pausas and Lavorel 2003). Functional groups in particular have been shown to be an effective approach to evaluating vegetation response to grazing-related disturbances (Friedel et al. 1988, McIntyre et al. 1995, Lavorel et al. 1997, Landsberg et al. 1999). In this study, the VIBI showed a much stronger response to the disturbance gradient than did the whole community analysis.

A major output of this project was the extension of the floristic quality assessment methodology to western Montana wetlands. Although not strictly a functional classification, the concept of floristic quality, which is based on the fidelity of plant species to high-integrity habitats, can be used as a broadly integrative measure of site condition. It is especially pertinent for measuring human-associated stresses, as the tolerance of plant species to anthropogenic disturbance is an implicit criterion in the assignment of *C*-values. The utility of the floristic quality assessment index as a vegetation metric has been demonstrated in diverse wetland settings (Lopez and Fennessy 2002, DeKeyser et al. 2003, Cohen et al. 2004).

The FQAI has been criticized for the subjective assignment of *C*-values. In a study of prairie potholes using *C*-values assigned by expert opinion for the Dakotas (Northern Great Plains Floristic Quality Assessment Panel 2001), Mushet et al. (2002) found that subjectively assigned *C*-values were good indicators of species response and gave comparable results to *C*-values that had been objectively derived. Although the *C*-values used in this study have not been independently verified, they are likely to be similarly robust.

One surprising finding was the relatively poor performance of the floristic quality assessment index, at least as traditionally calculated. The FQAI is usually computed based on species presence/absence data, and this approach has been found to be a good indicator of site condition (Lopez and Fennessy 2002, Cohen et al. 2004). However, in this study, the species richness-based FQAI exhibited a weak correlation with disturbance. Including exotic species in the richness-based FQAI provided a marginal improvement. In contrast, the FQAI weighted by each species' relative cover was strongly correlated with the disturbance gradient. This is in contrast to Cohen et al. (2004) who found no improvement in FQAI performance when using frequency-weighted abundance values. The improvement in FQAI performance with cover-weighted values in this study may be due in part to the increased dominance of a relatively few exotic species with low *C*-values in disturbed sites. These species include Kentucky bluegrass, redtop (*Agrostis gigantea* Roth), white clover (*Trifolium* *repens* L.), and common dandelion (*Taraxacum officinale* G.H. Weber ex Wiggers).

Although in this study the FQAI was used as a component in a multimetric index, floristic quality assessments should have broader applicability. In assigning *C*-values, the expert panel was not limited to the species sampled in this study but considered all species likely to occur in western Montana wetlands (the species list was taken from Lesica and Husby (2001, Appendix A)). Thus, the FQAI and related measures of floristic quality can be tested and applied as a stand-alone indicator of site condition to all wetland types in western Montana, not just the limited subset considered here. Further testing should be done to compare the relative utility of the presence-absence and cover-weighted formulations of the FQAI.

Recommendations for Future Improvements

An important next step is to validate the VIBI and to expand its applicability. This study examined vegetation response to a single, albeit complex, stressor. The VIBI should be validated at additional environmentally similar sites where grazing is the primary human stressor. However, to be broadly applicable, the VIBI will need to be generalized so that it is responsive to other anthropogenic stressors, especially those that modify hydrology. Some applicability of the VIBI as formulated here should be expected, as one of the effects of overgrazing can be bank erosion and stream channel downcutting, which can affect hydrology and make a site "drier." Functionally, there may be some overlap between grazing-induced stresses on the vegetation community and other stressors that cause hydrologic alterations. Several of the metrics developed here, including willow seedling density, absolute cover of willow seedlings and young willows, and relative cover of hydrophytes, should also be responsive to hydrologic stressors.

The site selection procedure used in this study could also be improved. Sites were initially selected based on proper functioning condition assessments. PFC categories, which were assumed to be indicative of general site condition, were used to establish a broad disturbance gradient for sampling purposes. However, PFC assessments may not adequately differentiate between moderately and highly disturbed sites, at least when grazing is the primary stressor. This is evidenced by the lack of difference in mean PCA-derived disturbance scores between the functioning at risk and nonfunctioning categories. This lack of association may reflect in part the different purposes of these measures of disturbance: the composite disturbance gradient was constructed by finding linear combinations of variables that were expected to measure different aspects of grazing-associated stresses, while the PFC is a more general method to evaluate site condition.

Another aspect of the site selection process should be reconsidered: in defining the site selection criteria for this study, the sampling universe was restricted to sites able to support tall woody vegetation (i.e., willows). Site potential was verified by either previous BLM surveys, which characterized sites by Hansen et al.'s (1995) vegetation community classification or by review of U.S. Geological Survey digital orthophoto imagery. This was done to focus on the most typical stream reaches (which do support woody vegetation) and to reduce environmental heterogeneity by excluding forested, sagebrush, or herbaceous-dominated stream reaches (i.e., sedge meadows). Although reducing environmental heterogeneity is an important design consideration when developing multimetric indices (Teels and Adamus 2002), an unfortunate result of this stratification was the potential undersampling of extremely disturbed sites where grazing had completely removed woody cover. All the sites sampled in this study, even the most heavily disturbed, supported willow cover, although at heavily disturbed sites this cover was usually exclusively provided by mature or senescent willows.

Another improvement would be to develop a model- or rule-based scoring method to measure a site's level of disturbance. The PCA-based method employed in this study had the benefit of providing a quantitative and objective measure of site disturbance, and it was a good first step to understand the relative importance of and interactions between the measured disturbance variables. However, a limitation to this approach is that the specific results are idiosyncratic to the collected dataset. A next step would either be to model the composite disturbance gradient (e.g., generalize the results of the PCA by finding explanatory equations) or to develop a rule-based procedure. Lopez and Fennessy (2002) used a rule-based approach to describe wetland disturbance: wetlands were ordered into one of 24 categories based on buffer conditions and presence of hydrologic modifications. Ohio EPA used their rapid assessment method as a measure of site disturbance (Mack et al. 2000). (This last approach would be somewhat circular, as the VIBI is meant to be used to validate DEQ's rapid assessment.) Developing a more generalized disturbance measure will become more of an issue as the VIBI's reference domain broadens to include greater environmental and anthropogenic heterogeneity.

A parallel issue is to limit disturbance factors to variables that are measurable at all sites. For example, three of the disturbance factors used here, amount bare ground, bank stability, and browse intensity, were measured on-site. The fourth, livestock use (AUM), was readily available only because sites were sampled on public land. Therefore, AUM is not likely to be easily generalized and should probably be removed from future studies.

Finally, there is the question of improving the broader utility of the VIBI. As the VIBI is sufficiently validated (and possibly modified), it will become a useful tool to assess riparian area condition and will provide validation for rapid assessments. However, because many of the metrics require the entire vegetation community to be enumerated, the VIBI requires extensive botanical expertise and time. An ongoing goal in refining the VIBI should be to use more easily measured metrics that can perhaps be ultimately incorporated into the rapid assessment method. Current examples are willow seedling density and cover of young and seedling willows. Cohen et al. (2005) used classification and regression trees to identify indicator species for different wetland condition categories, thereby lessening the botanical expertise needed to assess wetland condition. Likewise, the indicator species recognized here may form the basis of identifying key plant species that are consistently associated with certain levels of disturbance.

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Appendix A. Coefficients of conservation for selected wetland plants that occur in western Montana.

Appendix A. Coefficients of conservation for selected wetland plants that occur in western Montana.

Coefficients of conservatism were assigned to 747 plant species known to occur in wetlands in western Montana. Species were selected based on the species list in Lesica and Husby (2001, Appendix A). Coefficients for a few additional non-wetland species were assigned because they were sampled in the course of the study. Coefficients were determined by a panel of expert botanists. Panel members were Stephen Cooper (Vegetation Ecologist, Montana Natural Heritage Program), Marc Jones (Ecologist, Montana Natural Heritage Program), Peter Lesica (Botanical Consultant), Mary Manning (Vegetation Ecologist, U.S. Forest Service), Scott Mincemoyer (Botanist, Montana Natural Heritage Program), John Pierce (Botanical Consultant), and Steve Shelly (Regional Botanist, U.S. Forest Service). Coefficients for 345 species were assigned by the entire committee; coefficients for the remaining 402 species were assigned by Marc Jones, Peter Lesica, and John Pierce. Nomenclature follows the federal naming standard (Natural Resources Conservation Service 2004). For unfamiliar names, a partial synonymy can be found by consulting the PLANTS database at http://plants.usda.gov.

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Coefficients of conservatism (*C*) for 747 wetland plants species known to occur in western Montana.

C	Scientific Name	Common Name
4	*Acer glabrum* Torr.	Rocky Mountain maple
2	*Acer negundo* L.	boxelder
6	*Achnatherum nelsonii* (Scribn.) Barkworth	Columbia needlegrass
5	*Aconitum columbianum* Nutt.	Columbian monkshood
7	*Actaea rubra* (Ait.) Willd.	red baneberry
7	*Adiantum aleuticum* (Rupr.) Paris	Aleutian maidenhair
5	*Agoseris aurantiaca* (Hook.) Greene	orange agoseris
4	*Agoseris glauca* (Pursh) Raf.	pale agoseris
3	*Agrostis exarata* Trin.	spike bentgrass
1	*Agrostis gigantea* Roth	redtop
8	*Agrostis humilis* Vasey	alpine bentgrass
2	*Agrostis scabra* Willd.	rough bentgrass
6	*Allium brevistylum* S. Wats.	shortstyle onion
6	*Allium schoenoprasum* L.	wild chives
6	*Alnus incana* (L.) Moench	gray alder
6	*Alnus viridis* (Vill.) Lam. & DC.	green alder
4	*Alopecurus aequalis* Sobol.	shortawn foxtail
6	*Alopecurus alpinus* Sm.	boreal alopecurus
4	*Alopecurus carolinianus* Walt.	Carolina foxtail
2	*Alopecurus geniculatus* L.	water foxtail
0	*Alopecurus pratensis* L.	meadow foxtail
0	*Amaranthus blitoides* S. Wats.	mat amaranth
7	*Amaranthus californicus* (Moq.) S. Wats.	California amaranth
3	*Ambrosia psilostachya* DC.	Cuman ragweed
1	*Ambrosia trifida* L.	great ragweed
10	*Amerorchis rotundifolia* (Banks ex Pursh) Hultén	roundleaf orchid
2	*Androsace filiformis* Retz.	filiform rockjasmine
6	*Anemone parviflora* Michx.	smallflowered anemone
5	*Angelica arguta* Nutt.	Lyall's angelica
7	*Angelica dawsonii* S. Wats.	Dawson's angelica
4	*Angelica pinnata* S. Wats.	small-leaf angelica
3	*Antennaria corymbosa* E. Nels.	flat-top pussytoes
3	*Antennaria microphylla* Rydb.	littleleaf pussytoes
4	*Apocynum cannabinum* L.	Indianhemp
6	*Aquilegia caerulea* James	Colorado blue columbine
6	*Aquilegia formosa* Fisch. ex DC.	western columbine
0	*Arenaria serpyllifolia* L.	thymeleaf sandwort
3	*Argentina anserina* (L.) Rydb.	silverweed cinquefoil
5	*Arnica amplexicaulis* Nutt.	clasping arnica
5	*Arnica chamissonis* Less.	Chamisso arnica
7	*Arnica longifolia* D.C. Eat.	spearleaf arnica
6	*Arnica mollis* Hook.	hairy arnica
2	*Artemisia biennis* Willd.	biennial wormwood
4	*Artemisia cana* Pursh	silver sagebrush
7	*Artemisia lindleyana* Bess.	Columbia River wormwood
3	*Artemisia ludoviciana* Nutt.	white sagebrush
5	*Artemisia tridentata* Nutt. ssp. *tridentata*	basin big sagebrush
3	*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle	mountain big sagebrush

C	Scientific Name	Common Name
4	*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young	Wyoming big sagebrush
0	*Asclepias speciosa* Torr.	showy milkweed
3	*Astragalus agrestis* Dougl. ex G. Don	purple milkvetch
6	*Astragalus americanus* (Hook.) M.E. Jones	American milkvetch
3	*Astragalus canadensis* L.	Canadian milkvetch
5	*Athyrium filix-femina* (L.) Roth	common ladyfern
0	*Atriplex patula* L.	spear saltbush
5	*Atriplex truncata* (Torr. ex S. Wats.) Gray	wedgescale saltbush
7	*Bacopa rotundifolia* (Michx.) Wettst.	disk waterhyssop
4	*Barbarea orthoceras* Ledeb.	American yellowrocket
0	*Barbarea vulgaris* Ait. f.	garden yellowrocket
4	*Beckmannia syzigachne* (Steud.) Fern.	American sloughgrass
7	*Berula erecta* (Huds.) Coville	cutleaf waterparsnip
8	*Betula nana* L.	dwarf birch
5	*Betula occidentalis* Hook.	water birch
4	*Bidens cernua* L.	nodding beggartick
6	*Bidens tripartita* L.	threelobe beggarticks
6	*Bidens vulgata* Greene	big devils beggartick
6	*Botrychium lanceolatum* (Gmel.) Angstr.	lanceleaf grapefern
4	*Botrychium lunaria* (L.) Sw.	common moonwort
8	*Botrychium multifidum* (Gmel.) Trev.	leathery grapefern
7	*Botrychium pinnatum* St. John	northern moonwort
6	*Botrychium simplex* E. Hitchc.	little grapefern
7	*Boykinia major* Gray	large boykinia
6	*Bromus ciliatus* L.	fringed brome
0	*Bromus inermis* Leyss.	smooth brome
5	*Bromus marginatus* Nees ex Steud.	mountain brome
5	*Calamagrostis canadensis* (Michx.) Beauv.	bluejoint
6	*Calamagrostis stricta* (Timm) Koel.	slimstem reedgrass
6	*Callitriche hermaphroditica* L.	northern water-starwort
3	*Callitriche heterophylla* Pursh	twoheaded water-starwort
7	*Caltha leptosepala* DC.	white marsh marigold
6	*Calypso bulbosa* (L.) Oakes	fairy slipper
6	*Camassia quamash* (Pursh) Greene	small camas
5	*Camissonia subacaulis* (Pursh) Raven	diffuseflower evening-primrose
7	*Campanula parryi* Gray	Parry's bellflower
3	*Campanula rotundifolia* L.	bluebell bellflower
9	*Campanula uniflora* L.	arctic bellflower
6	*Canadanthus modestus* (Lindl.) Nesom	giant mountain aster
7	*Cardamine breweri* S. Wats.	Brewer's bittercress
3	*Cardamine oligosperma* Nutt.	little western bittercress
3	*Cardamine pensylvanica* Muhl. ex Willd.	Pennsylvania bittercress
5	*Carex amplifolia* Boott	bigleaf sedge
6	*Carex aperta* Boott	Columbian sedge
5	*Carex aquatilis* Wahlenb.	water sedge
6	*Carex arcta* Boott	northern cluster sedge
5	*Carex atherodes* Spreng.	wheat sedge
4	*Carex athrostachya* Olney	slenderbeak sedge

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7	*Carex atratiformis* Britt.	scabrous black sedge
6	*Carex aurea* Nutt.	golden sedge
7	*Carex bebbii* Olney ex Fern.	Bebb's sedge
4	*Carex brevior* (Dewey) Mackenzie	shortbeak sedge
8	*Carex brunnescens* (Pers.) Poir.	brownish sedge
8	*Carex buxbaumii* Wahlenb.	Buxbaum's sedge
8	*Carex canescens* L.	silvery sedge
8	*Carex capillaris* L.	hairlike sedge
7	*Carex capitata* L.	capitate sedge
9	*Carex chordorrhiza* Ehrh. ex L. f.	creeping sedge
7	*Carex comosa* Boott	longhair sedge
6	*Carex crawei* Dewey	Crawe's sedge
7	*Carex cusickii* Mackenzie ex Piper & Beattie	Cusick's sedge
6	*Carex deweyana* Schwein.	Dewey sedge
8	*Carex diandra* Schrank	lesser panicled sedge
6	*Carex disperma* Dewey	softleaf sedge
8	*Carex echinata* Murr.	star sedge
7	*Carex flava* L.	yellow sedge
7	*Carex foenea* Willd.	dryspike sedge
9	*Carex gynocrates* Wormsk. ex Drej.	northern bog sedge
7	*Carex heteroneura* W. Boott	different nerve sedge
5	*Carex hystericina* Muhl. ex Willd.	bottlebrush sedge
7	*Carex idahoa* Bailey	Idaho sedge
7	*Carex illota* Bailey	sheep sedge
8	*Carex interior* Bailey	inland sedge
9	*Carex lachenalii* Schkuhr	twotipped sedge
9	*Carex lacustris* Willd.	hairy sedge
5	*Carex laeviconica* Dewey	smoothcone sedge
6	*Carex laeviculmis* Meinsh.	smoothstem sedge
7	*Carex lasiocarpa* Ehrh.	woollyfruit sedge
5	*Carex lenticularis* Michx.	lakeshore sedge
8	*Carex leptalea* Wahlenb.	bristlystalked sedge
9	*Carex limosa* L.	mud sedge
9	*Carex livida* (Wahlenb.) Willd.	livid sedge
7	*Carex luzulina* Olney	woodrush sedge
3	*Carex mertensii* Prescott ex Bong.	Mertens' sedge
3	*Carex microptera* Mackenzie	smallwing sedge
3	*Carex nebrascensis* Dewey	Nebraska sedge
7	*Carex nelsonii* Mackenzie	Nelson's sedge
7	*Carex neurophora* Mackenzie	alpine nerve sedge
7	*Carex nigricans* C.A. Mey.	black alpine sedge
8	*Carex norvegica* Retz.	Norway sedge
7	*Carex nova* Bailey	black sedge
7	*Carex pachystachya* Cham. ex Steud.	chamisso sedge
5	*Carex parryana* Dewey	Parry's sedge
4	*Carex pellita* Muhl ex Willd.	woolly sedge
7	*Carex podocarpa* R. Br.	shortstalk sedge
7	*Carex praeceptorium* Mackenzie	early sedge
4	*Carex praegracilis* W. Boott	clustered field sedge

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4	*Carex praticola* Rydb.	meadow sedge
7	*Carex pyrenaica* Wahlenb.	Pyrenean sedge
7	*Carex sartwellii* Dewey	Sartwell's sedge
8	*Carex saxatilis* L.	rock sedge
7	*Carex scoparia* Schkuhr ex Willd.	broom sedge
8	*Carex scopulorum* Holm	mountain sedge
8	*Carex simulata* Mackenzie	analogue sedge
7	*Carex spectabilis* Dewey	showy sedge
8	*Carex sprengelii* Dewey ex Spreng.	Sprengel's sedge
4	*Carex stipata* Muhl. ex Willd.	owlfruit sedge
8	*Carex sychnocephala* Carey	manyhead sedge
10	*Carex tenuiflora* Wahlenb.	sparseflower sedge
9	*Carex torreyi* Tuckerman	Torrey's sedge
3	*Carex utriculata* Boott	Northwest Territory sedge
5	*Carex vesicaria* L.	blister sedge
8	*Carex viridula* Michx.	little green sedge
6	*Carex vulpinoidea* Michx.	fox sedge
4	*Castilleja miniata* Dougl. ex Hook.	giant red Indian paintbrush
3	*Castilleja minor* (Gray) Gray	lesser Indian paintbrush
7	*Castilleja occidentalis* Torr.	western Indian paintbrush
7	*Castilleja rhexiifolia* Rydb.	splitleaf Indian paintbrush
7	*Castilleja sulphurea* Rydb.	sulphur Indian paintbrush
3	*Catabrosa aquatica* (L.) Beauv.	water whorlgrass
3	*Ceratophyllum demersum* L.	coon's tail
1	*Chamerion angustifolium* (L.) Holub	fireweed
0	*Chenopodium album* L.	lambsquarters
3	*Chenopodium rubrum* L.	red goosefoot
4	*Chrysosplenium tetrandrum* (Lund ex Malmgr.) Th. Fries	northern golden saxifrage
7	*Cicuta bulbifera* L.	bulblet-bearing water hemlock
4	*Cicuta douglasii* (DC.) Coult. & Rose	western water hemlock
3	*Cicuta maculata* L.	spotted water hemlock
5	*Circaea alpina* L.	small enchanter's nightshade
0	*Cirsium arvense* (L.) Scop.	Canada thistle
5	*Cirsium scariosum* Nutt.	meadow thistle
4	*Cirsium undulatum* (Nutt.) Spreng.	wavyleaf thistle
0	*Cirsium vulgare* (Savi) Ten.	bull thistle
2	*Claytonia perfoliata* Donn ex Willd.	miner's lettuce
5	*Claytonia sibirica* L.	Siberian springbeauty
6	*Coeloglossum viride* (L.) Hartman	longbract frog orchid
3	*Collomia linearis* Nutt.	tiny trumpet
7	*Comarum palustre* L.	purple marshlocks
0	*Conium maculatum* L.	poison hemlock
8	*Corallorrhiza trifida* Chatelain	yellow coralroot
9	*Corallorrhiza wisteriana* Conrad	spring coralroot
6	*Coreopsis tinctoria* Nutt.	golden tickseed
7	*Cornus canadensis* L.	bunchberry dogwood
5	*Cornus sericea* L.	redosier dogwood
5	*Crataegus douglasii* Lindl.	black hawthorn
5	*Crepis runcinata* (James) Torr. & Gray	fiddleleaf hawksbeard

C	Scientific Name	Common Name
0	*Cynoglossum officinale* L.	gypsyflower
8	*Cyperus schweinitzii* Torr.	Schweinitz's flatsedge
7	*Cypripedium fasciculatum* Kellogg ex S. Wats.	clustered lady's slipper
9	*Cypripedium parviflorum* Salisb.	lesser yellow lady's slipper
10	*Cypripedium passerinum* Richards.	sparrowegg lady's slipper
10	*Cystopteris montana* (Lam.) Bernh. ex Desv.	mountain bladderfern
5	*Danthonia intermedia* Vasey	timber oatgrass
3	*Dasiphora floribunda* (Pursh) Kartesz, comb. nov. ined.	shrubby cinquefoil
7	*Delphinium depauperatum* Nutt.	slim larkspur
6	*Delphinium glaucum* S. Wats.	Sierra larkspur
7	*Deschampsia caespitosa* (L.) Beauv.	tufted hairgrass
5	*Deschampsia danthonioides* (Trin.) Munro	annual hairgrass
4	*Deschampsia elongata* (Hook.) Munro	slender hairgrass
9	*Dichanthelium acuminatum* (Sw.) Gould & C.A. Clark var. *fasciculatum* (Torr.) Freckmann	western panicgrass
5	*Distichlis spicata* (L.) Greene	inland saltgrass
7	*Dodecatheon jeffreyi* Van Houtte	Sierrra shootingstar
5	*Dodecatheon pulchellum* (Raf.) Merr.	darkthroat shootingstar
7	*Draba aurea* Vahl ex Hornem.	golden draba
9	*Dryopteris cristata* (L.) Gray	crested woodfern
0	*Echinochloa muricata* (Beauv.) Fern.	rough barnyardgrass
5	*Echinocystis lobata* (Michx.) Torr. & Gray	wild cucumber
0	*Elaeagnus angustifolia* L.	Russian olive
6	*Elatine californica* Gray	California waterwort
6	*Elatine rubella* Rydb.	southwestern waterwort
4	*Eleocharis acicularis* (L.) Roemer & J.A. Schultes	needle spikerush
4	*Eleocharis palustris* (L.) Roemer & J.A. Schultes	common spikerush
7	*Eleocharis quinqueflora* (F.X. Hartmann) Schwarz	fewflower spikerush
9	*Eleocharis rostellata* (Torr.) Torr.	beaked spikerush
8	*Elodea bifoliata* St. John	twoleaf waterweed
7	*Elodea canadensis* Michx.	Canadian waterweed
4	*Elodea nuttallii* (Planch.) St. John	western waterweed
5	*Elymus canadensis* L.	Canada wildrye
5	*Elymus glaucus* Buckl.	blue wildrye
0	*Elymus repens* (L.) Gould	quackgrass
6	*Elymus submuticus* (Hook.) Smyth & Smyth	Virginia wildrye
5	*Elymus trachycaulus* (Link) Gould ex Shinners	slender wheatgrass
5	*Epilobium anagallidifolium* Lam.	pimpernel willowherb
3	*Epilobium ciliatum* Raf.	fringed willowherb
5	*Epilobium glaberrimum* Barbey	glaucus willowherb
7	*Epilobium palustre* L.	marsh willowherb
2	*Equisetum arvense* L.	field horsetail
6	*Equisetum fluviatile* L.	water horsetail
3	*Equisetum hyemale* L.	scouringrush horsetail
4	*Equisetum laevigatum* A. Braun	smooth horsetail
6	*Equisetum palustre* L.	marsh horsetail
6	*Equisetum pratense* Ehrh.	meadow horsetail
7	*Equisetum scirpoides* Michx.	dwarf scouringrush

C	Scientific Name	Common Name
5	*Equisetum variegatum* Schleich. ex F. Weber & D.M.H. Mohr	variegated scouringrush
4	*Eragrostis hypnoides* (Lam.) B.S.P.	teal lovegrass
4	*Eragrostis pectinacea* (Michx.) Nees ex Steud.	tufted lovegrass
2	*Ericameria nauseosa* (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush
5	*Erigeron acris* L.	bitter fleabane
6	*Erigeron coulteri* Porter	large mountain fleabane
3	*Erigeron flagellaris* Gray	trailing fleabane
6	*Erigeron gracilis* Rydb.	quill fleabane
8	*Erigeron humilis* Graham	arctic alpine fleabane
4	*Erigeron lonchophyllus* Hook.	shortray fleabane
7	*Erigeron peregrinus* (Banks ex Pursh) Greene	subalpine fleabane
3	*Erigeron philadelphicus* L.	Philadelphia fleabane
10	*Eriophorum scheuchzeri* Hoppe	white cottongrass
5	*Eupatorium maculatum* L.	spotted joepyeweed
7	*Euthamia graminifolia* (L.) Nutt.	flat-top goldentop
7	*Euthamia occidentalis* Nutt.	western goldentop
4	*Festuca idahoensis* Elmer	Idaho fescue
1	*Festuca rubra* L.	red fescue
7	*Festuca subulata* Trin.	bearded fescue
3	*Fragaria virginiana* Duchesne	Virginia strawberry
4	*Galium boreale* L.	northern bedstraw
2	*Galium mexicanum* Kunth	Mexican bedstraw
5	*Galium palustre* L.	common marsh bedstraw
6	*Galium trifidum* L.	threepetal bedstraw
6	*Galium triflorum* Michx.	fragrant bedstraw
8	*Gaultheria humifusa* (Graham) Rydb.	alpine spicywintergreen
8	*Gaultheria ovatifolia* Gray	western teaberry
6	*Gentiana affinis* Griseb.	pleated gentian
9	*Gentiana algida* Pallas	whitish gentian
7	*Gentiana calycosa* Griseb.	Rainier pleated gentian
10	*Gentiana glauca* Pallas	pale gentian
6	*Gentiana prostrata* Haenke	pygmy gentian
3	*Gentianella amarella* (L.) Boerner	autumn dwarf gentian
10	*Gentianella propinqua* (Richards.) J. Gillett	fourpart dwarf gentian
6	*Gentianella tenella* (Rottb.) Boerner	Dane's dwarf gentian
9	*Gentianopsis simplex* (Gray) Iltis	oneflower fringed gentian
8	*Gentianopsis thermalis* (Kuntze) Iltis	Rocky Mountain fringed gentian
5	*Geranium richardsonii* Fisch. & Trautv.	Richardson's geranium
4	*Geranium viscossisimum* Fisch. & Trautv.	Sticky geranium
6	*Geum aleppicum* Jacq.	yellow avens
5	*Geum macrophyllum* Willd.	largeleaf avens
7	*Geum rivale* L.	purple avens
5	*Glaux maritima* L.	sea milkwort
6	*Glyceria borealis* (Nash) Batchelder	small floating mannagrass
7	*Glyceria grandis* S. Wats.	American mannagrass
6	*Glyceria striata* (Lam.) A.S. Hitchc.	fowl mannagrass
3	*Glycyrrhiza lepidota* Pursh	American licorice
3	*Gnaphalium palustre* Nutt.	western marsh cudweed

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8	*Gratiola ebracteata* Benth. ex A. DC.	bractless hedgehyssop
8	*Gratiola neglecta* Torr.	clammy hedgehyssop
2	*Grindelia howellii* Steyermark	Howell's gumweed
2	*Grindelia squarrosa* (Pursh) Dunal	curlycup gumweed
7	*Gymnocarpium dryopteris* (L.) Newman	western oakfern
6	*Helenium autumnale* L.	common sneezeweed
7	*Helianthus nuttallii* Torr. & Gray	Nuttall's sunflower
5	*Heliotropium curassavicum* L.	salt heliotrope
5	*Heracleum maximum* Bartr.	common cowparsnip
9	*Hesperochiron pumilus* (Dougl. ex Griseb.) Porter	dwarf hesperochiron
8	*Hierochloe hirta* (Schrank) Borbás	northern sweetgrass
6	*Hippuris vulgaris* L.	common mare's-tail
5	*Hordeum brachyantherum* Nevski	meadow barley
2	*Hordeum jubatum* L.	foxtail barley
9	*Howellia aquatilis* Gray	water howellia
8	*Hypericum majus* (Gray) Britt.	large St. Johnswort
7	*Hypericum scouleri* Hook.	Scouler's St. Johnswort
3	*Impatiens ecalcarata* Blank.	spurless touch-me-not
2	*Iris missouriensis* Nutt.	Rocky Mountain iris
0	*Iris pseudacorus* L.	paleyellow iris
7	*Isoetes bolanderi* Engelm.	Bolander's quillwort
8	*Isoetes howellii* Engelm.	Howell's quillwort
3	*Iva axillaris* Pursh	povertyweed
3	*Iva xanthifolia* Nutt.	giant sumpweed
5	*Juncus acuminatus* Michx.	tapertip rush
9	*Juncus albescens* (Lange) Fern.	northern white rush
7	*Juncus alpinoarticulatus* Chaix	northern green rush
7	*Juncus articulatus* L.	jointleaf rush
3	*Juncus balticus* Willd.	Baltic rush
9	*Juncus biglumis* L.	twoflowered rush
1	*Juncus bufonius* L.	toad rush
9	*Juncus castaneus* Sm.	chestnut rush
2	*Juncus compressus* Jacq.	roundfruit rush
2	*Juncus confusus* Coville	Colorado rush
7	*Juncus drummondii* E. Mey.	Drummond's rush
6	*Juncus effusus* L.	common rush
4	*Juncus ensifolius* Wikstr.	swordleaf rush
7	*Juncus filiformis* L.	thread rush
6	*Juncus hallii* Engelm.	Hall's rush
5	*Juncus longistylis* Torr.	longstyle rush
7	*Juncus mertensianus* Bong.	Mertens' rush
6	*Juncus nevadensis* S. Wats.	Sierra rush
8	*Juncus nevadensis* Watson	Sierra rush
5	*Juncus nodosus* L.	knotted rush
7	*Juncus parryi* Engelm.	Parry's rush
3	*Juncus tenuis* Willd.	poverty rush
5	*Juncus torreyi* Coville	Torrey's rush
6	*Juncus tracyi* Rydb.	Tracy's rush
8	*Juncus triglumis* L.	threehulled rush

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7	*Kobresia myosuroides* (Vill.) Fiori	Bellardi bog sedge
9	*Kobresia simpliciuscula* (Wahlenb.) Mackenzie	simple bog sedge
0	*Kochia scoparia* (L.) Schrad.	Mexican-fireweed
3	*Lactuca biennis* (Moench) Fern.	tall blue lettuce
4	*Lactuca tatarica* (L.) C.A. Mey.	blue lettuce
7	*Ledum glandulosum* Nutt.	western Labrador tea
8	*Leersia oryzoides* (L.) Sw.	rice cutgrass
2	*Lemna minor* L.	common duckweed
5	*Lemna trisulca* L.	star duckweed
8	*Leptarrhena pyrolifolia* (D. Don) R. Br. ex Ser.	fireleaf leptarrhena
4	*Leptochloa fusca* (L.) Kunth ssp. *fascicularis* (Lam.) N. Snow	bearded sprangletop
5	*Leymus cinereus* (Scribn. & Merr.) A. Löve	basin wildrye
6	*Ligusticum canbyi* Coult. & Rose	Canby's licorice-root
7	*Ligusticum tenuifolium* S. Wats.	Idaho licorice-root
7	*Ligusticum verticillatum* (Hook.) Coult. & Rose ex Rose	northern licorice-root
9	*Lilium philadelphicum* L.	wood lily
4	*Limosella aquatica* L.	water mudwort
9	*Listera borealis* Morong	northern twayblade
7	*Listera caurina* Piper	northwestern twayblade
8	*Listera convallarioides* (Sw.) Nutt. ex Ell.	broadlipped twayblade
7	*Listera cordata* (L.) R. Br. ex Ait. f.	heartleaf twayblade
7	*Lloydia serotina* (L.) Reichenb.	common alplily
5	*Lobelia kalmii* L.	Ontario lobelia
0	*Lolium pratense* (Huds.) S.J. Darbyshire	meadow ryegrass
6	*Lomatogonium rotatum* (L.) Fries ex Fern.	marsh felwort
8	*Lonicera caerulea* L.	sweetberry honeysuckle
5	*Lonicera involucrata* Banks ex Spreng.	twinberry honeysuckle
0	*Lotus corniculatus* L.	birdfoot deervetch
5	*Lupinus aridus* Dougl.	desert lupine
6	*Lupinus polyphyllus* Lindl.	bigleaf lupine
7	*Luzula parviflora* (Ehrh.) Desv.	smallflowered woodrush
8	*Luzula piperi* (Coville) M.E. Jones	Piper's woodrush
9	*Lycopodium alpinum* L.	alpine clubmoss
6	*Lycopodium annotinum* L.	stiff clubmoss
10	*Lycopodium clavatum* L.	running clubmoss
7	*Lycopodium complanatum* L.	groundcedar
8	*Lycopus americanus* Muhl. ex W. Bart.	American water horehound
6	*Lycopus asper* Greene	rough bugleweed
9	*Lycopus uniflorus* Michx.	northern bugleweed
8	*Lysichiton americanus* Hultén & St. John	American skunkcabbage
7	*Lysimachia ciliata* L.	fringed loosestrife
8	*Lysimachia thyrsiflora* L.	tufted loosestrife
0	*Lythrum salicaria* L.	purple loosestrife
4	*Maianthemum racemosum* (L.) Link	feathery false lily of the vally
4	*Maianthemum stellatum* (L.) Link	starry false lily of the vally
4	*Marsilea vestita* Hook. & Grev.	hairy waterclover
6	*Melampyrum lineare* Desr.	narrowleaf cowwheat
7	*Melica spectabilis* Scribn.	purple oniongrass

C	Scientific Name	Common Name
3	*Mentha arvensis* L.	wild mint
0	*Mentha spicata* L.	spearmint
6	*Mertensia ciliata* (James ex Torr.) G. Don	tall fringed bluebells
7	*Mertensia paniculata* (Ait.) G. Don	tall bluebells
3	*Mimulus breviflorus* Piper	shortflower monkeyflower
3	*Mimulus floribundus* Lindl.	manyflowered monkeyflower
5	*Mimulus guttatus* DC.	seep monkeyflower
7	*Mimulus lewisii* Pursh	purple monkeyflower
3	*Mimulus moschatus* Dougl. ex Lindl.	muskflower
10	*Mimulus primuloides* Benth.	primrose monkeyflower
7	*Mimulus tilingii* Regel	Tiling's monkeyflower
5	*Minuartia rubella* (Wahlenb.) Hiern.	beautiful sandwort
7	*Mitella breweri* Gray	Brewer's miterwort
8	*Mitella nuda* L.	naked miterwort
7	*Mitella pentandra* Hook.	fivestamen miterwort
6	*Mitella stauropetala* Piper	smallflower miterwort
5	*Moehringia lateriflora* (L.) Fenzl	bluntleaf sandwort
0	*Mollugo verticillata* L.	green carpetweed
8	*Moneses uniflora* (L.) Gray	single delight
0	*Monolepis nuttalliana* (J.A. Schultes) Greene	Nuttall's povertyweed
4	*Montia chamissoi* (Ledeb. ex Spreng.) Greene	water minerslettuce
2	*Montia dichotoma* (Nutt.) T.J. Howell	dwarf minerslettuce
2	*Montia parvifolia* (Moc. ex DC.) Greene	littleleaf minerslettuce
7	*Muhlenbergia asperifolia* (Nees & Meyen ex Trin.) Parodi	scratchgrass
4	*Muhlenbergia filiformis* (Thurb. ex S. Wats.) Rydb.	pullup muhly
8	*Muhlenbergia glomerata* (Willd.) Trin.	spiked muhly
2	*Muhlenbergia minutissima* (Steud.) Swallen	annual muhly
4	*Muhlenbergia richardsonis* (Trin.) Rydb.	mat muhly
0	*Myosotis arvensis* (L.) Hill	field forget-me-not
7	*Myosotis asiatica* (Vesterg.) Schischkin & Sergievskaja	Asian forget-me-not
4	*Myosotis laxa* Lehm.	bay forget-me-not
0	*Myosotis scorpioides* L.	true forget-me-not
4	*Myosurus apetalus* C. Gay	bristly mousetail
4	*Myosurus minimus* L.	tiny mousetail
4	*Myriophyllum verticillatum* L.	whorl-leaf watermilfoil
7	*Najas flexilis* (Willd.) Rostk. & Schmidt	nodding waternymph
6	*Navarretia intertexta* (Benth.) Hook.	needleleaf navarretia
0	*Nepeta cataria* L.	catnip
5	*Nuphar lutea* (L.) Sm.	yellow pond-lily
0	*Nymphaea odorata* Ait.	American white waterlily
9	*Nymphaea tetragona* Georgi	pygmy waterlily
2	*Oenothera flava* (A. Nels.) Garrett	yellow evening-primrose
1	*Oenothera villosa* Thunb.	hairy evening-primrose
4	*Ophioglossum pusillum* Raf.	northern adderstongue
7	*Oplopanax horridus* Miq.	devilsclub
4	*Osmorhiza berteroi* DC.	sweetcicely
6	*Osmorhiza occidentalis* (Nutt. ex Torr. & Gray) Torr.	western sweetroot
6	*Osmorhiza purpurea* (Coult. & Rose) Suksdorf	purple sweetroot
7	*Packera cymbalarioides* (Buek) W.A. Weber & A. Löve	cleftleaf groundsel

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8	*Packera debilis* (Nutt.) W.A. Weber & A. Löve	weak groundsel
6	*Packera indecora* (Greene) A.& D. Löve	elegant groundsel
5	*Packera paupercula* (Michx.) A.& D. Löve	balsam groundsel
7	*Packera pseudaurea* (Rydb.) W.A. Weber & A. Löve	falsegold groundsel
1	*Panicum capillare* L.	witchgrass
7	*Parnassia fimbriata* Koenig	fringed grass of Parnassus
9	*Parnassia kotzebuei* Cham. ex Spreng.	Kotzebue's grass of Parnassus
9	*Parnassia palustris* L. var. *parviflora* (DC.) Boivin	smallflower grass of Parnassus
7	*Parnassia palustris* L. var. *tenuis* Wahlenb.	marsh grass of Parnassus
3	*Pascopyrum smithii* (Rydb.) A. Löve	western wheatgrass
7	*Pedicularis groenlandica* Retz.	elephanthead lousewort
0	*Pennisetum glaucum* (L.) R. Br.	pearl millet
5	*Penstemon attenuatus* Dougl. ex Lindl.	sulphur penstemon
5	*Penstemon procerus* Dougl. ex Graham	littleflower penstemon
9	*Petasites frigidus* (L.) Fries	arctic sweet coltsfoot
8	*Petasites sagittatus* (Banks ex Pursh) Gray	arrowleaf sweet coltsfoot
0	*Phalaris arundinacea* L.	reed canarygrass
10	*Phippsia algida* (C.J. Phipps) R. Br.	icegrass
7	*Phleum alpinum* L.	alpine timothy
0	*Phleum pratense* L.	timothy
5	*Phlox kelseyi* Britt.	Kelsey's phlox
4	*Phragmites australis* (Cav.) Trin. ex Steud.	common reed
7	*Phyllodoce empetriformis* (Sm.) D. Don	pink mountainheath
7	*Phyllodoce glanduliflora* (Hook.) Coville	yellow mountainheath
7	*Physostegia parviflora* Nutt. ex Gray	western false dragonhead
4	*Picea engelmannii* Parry ex Engelm.	Engelmann spruce
9	*Pinguicula macroceras* Link	California butterwort
6	*Piperia unalascensis* (Spreng.) Rydb.	slender-spire orchid
2	*Plagiobothrys scouleri* (Hook. & Arn.) I.M. Johnston	Scouler's popcornflower
3	*Plantago elongata* Pursh	prairie plantain
7	*Plantago eriopoda* Torr.	redwool plantain
0	*Plantago lanceolata* L.	narrowleaf plantain
1	*Plantago major* L.	common plantain
5	*Platanthera dilatata* (Pursh) Lindl. ex Beck	scentbottle
8	*Platanthera hyperborea* (L.) Lindl.	northern green orchid
10	*Platanthera obtusata* (Banks ex Pursh) Lindl.	bluntleaved orchid
9	*Platanthera orbiculata* (Pursh) Lindl.	lesser roundleaved orchid
7	*Platanthera stricta* Lindl.	slender bog orchid
5	*Poa alpina* L.	alpine bluegrass
4	*Poa arida* Vasey	plains bluegrass
8	*Poa leptocoma* Trin.	marsh bluegrass
1	*Poa palustris* L.	fowl bluegrass
0	*Poa pratensis* L.	Kentucky bluegrass
3	*Poa secunda* J. Presl	Sandberg bluegrass
6	*Polemonium occidentale* Greene	western polemonium
6	*Polygonum amphibium* L.	water knotweed
1	*Polygonum aviculare* L.	prostrate knotweed
6	*Polygonum bistortoides* Pursh	American bistort
0	*Polygonum convolvulus* L.	black bindweed

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3	*Polygonum douglasii* Greene	Douglas' knotweed
0	*Polygonum erectum* L.	erect knotweed
1	*Polygonum lapathifolium* L.	curlytop knotweed
1	*Polygonum persicaria* L.	spotted ladysthumb
4	*Polygonum polygaloides* Wallich ex Meisn.	milkwort knotweed
7	*Polygonum viviparum* L.	alpine bistort
5	*Populus ×acuminata* Rydb. (pro sp.)	lanceleaf cottonwood
5	*Populus angustifolia* James	narrowleaf cottonwood
5	*Populus balsamifera* L. ssp. *trichocarpa* (Torr. & Gray ex Hook.) Brayshaw	black cottonwood
4	*Populus deltoides* Bartr. ex Marsh. ssp. *monilifera* (Ait.) Eckenwalder	plains cottonwood
5	*Populus tremuloides* Michx.	quaking aspen
0	*Portulaca oleracea* L.	little hogweed
7	*Potamogeton alpinus* Balbis	alpine pondweed
10	*Potamogeton amplifolius* Tuckerman	largeleaf pondweed
1	*Potamogeton crispus* L.	curly pondweed
7	*Potamogeton friesii* Rupr.	Fries' pondweed
6	*Potamogeton gramineus* L.	variableleaf pondweed
8	*Potamogeton obtusifolius* Mert. & Koch	bluntleaf pondweed
7	*Potamogeton pusillus* L.	small pondweed
6	*Potamogeton richardsonii* (Benn.) Rydb.	Richardson's pondweed
9	*Potamogeton zosteriformis* Fern.	flatstem pondweed
4	*Potentilla biennis* Greene	biennial cinquefoil
6	*Potentilla diversifolia* Lehm.	varileaf cinquefoil
6	*Potentilla glandulosa* Lindl.	sticky cinquefoil
4	*Potentilla gracilis* Dougl. ex Hook.	slender cinquefoil
1	*Potentilla norvegica* L.	Norwegian cinquefoil
5	*Potentilla paradoxa* Nutt.	Paradox cinquefoil
4	*Potentilla rivalis* Nutt.	brook cinquefoil
5	*Primula incana* M.E. Jones	silvery primrose
8	*Primula parryi* Gray	Parry's primrose
2	*Prunella vulgaris* L.	common selfheal
3	*Prunus virginiana* L.	chokecherry
3	*Pseudognaphalium stramineum* (Kunth) W.A. Weber	cottonbatting plant
8	*Psilocarphus brevissimus* Nutt.	short woollyheads
4	*Puccinellia distans* (Jacq.) Parl.	weeping alkaligrass
6	*Puccinellia nuttalliana* (J.A. Schultes) A.S. Hitchc.	Nuttall's alkaligrass
6	*Pyrola asarifolia* Michx.	liverleaf wintergreen
8	*Pyrola chlorantha* Sw.	greenflowered wintergreen
4	*Pyrrocoma integrifolia* (Porter ex Gray) Greene	manysted goldenweed
4	*Pyrrocoma lanceolata* (Hook.) Greene	lanceleaf goldenweed
2	*Pyrrocoma uniflora* (Hook.) Greene	plantain goldenweed
3	*Ranunculus abortivus* L.	littleleaf buttercup
6	*Ranunculus acriformis* Gray	sharpleaf buttercup
0	*Ranunculus acris* L.	tall buttercup
7	*Ranunculus alismifolius* Geyer ex Benth.	plantainleaf buttercup
4	*Ranunculus aquatilis* L.	whitewater crowfoot
9	*Ranunculus cardiophyllus* Hook.	heartleaf buttercup

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3	*Ranunculus cymbalaria* Pursh	alkali buttercup
7	*Ranunculus eschscholtzii* Schlecht.	Eschscholtz's buttercup
4	*Ranunculus flammula* L.	greater creeping spearwort
4	*Ranunculus glaberrimus* Hook.	sagebrush buttercup
4	*Ranunculus gmelinii* DC.	Gmelin's buttercup
9	*Ranunculus hyperboreus* Rottb.	high northern buttercup
6	*Ranunculus inamoenus* Greene	graceful buttercup
5	*Ranunculus macounii* Britt.	Macoun's buttercup
8	*Ranunculus orthorhynchus* Hook.	straightbeak buttercup
9	*Ranunculus pedatifidus* Sm.	surefoot buttercup
7	*Ranunculus populago* Greene	popular buttercup
9	*Ranunculus pygmaeus* Wahlenb.	pygmy buttercup
0	*Ranunculus repens* L.	creeping buttercup
4	*Ranunculus sceleratus* L.	cursed buttercup
2	*Ranunculus uncinatus* D. Don ex G. Don	woodland buttercup
9	*Ranunculus verecundus* B.L. Robins. ex Piper	wetslope buttercup
4	*Rhamnus alnifolia* L'Hér.	alderleaf buckthorn
8	*Rhodiola rhodantha* (Gray) Jacobsen	redpod stonecrop
8	*Rhododendron albiflorum* Hook.	Cascade azalea
6	*Ribes americanum* P. Mill.	American black currant
5	*Ribes aureum* Pursh	golden currant
7	*Ribes hudsonianum* Richards.	northern black currant
5	*Ribes inerme* Rydb.	whitestem gooseberry
6	*Ribes lacustre* (Pers.) Poir.	prickly currant
6	*Ribes oxyacanthoides* L.	Canadian gooseberry
10	*Romanzoffia sitchensis* Bong.	Sitka mistmaiden
4	*Rorippa alpina* (S. Wats.) Rydb.	alpine yellowcress
4	*Rorippa curvipes* Greene	bluntleaf yellowcress
4	*Rorippa nasturtium-aquaticum* (L.) Hayek	watercress
4	*Rorippa palustris* (L.) Bess.	bog yellowcress
3	*Rotala ramosior* (L.) Koehne	lowland rotala
10	*Rubus arcticus* L. ssp. *acaulis* (Michx.) Focke	dwarf raspberry
7	*Rubus pubescens* Raf.	dwarf red blackberry
5	*Rudbeckia laciniata* L.	cutleaf coneflower
4	*Rudbeckia occidentalis* Nutt.	western coneflower
0	*Rumex acetosella* L.	common sheep sorrel
7	*Rumex aquaticus* L.	western dock
0	*Rumex crispus* L.	curly dock
6	*Rumex maritimus* L.	golden dock
7	*Rumex salicifolius* Weinm.	willow dock
8	*Ruppia cirrhosa* (Petag.) Grande	spiral ditchgrass
1	*Sagina procumbens* L.	birdeye pearlwort
3	*Sagina saginoides* (L.) Karst.	arctic pearlwort
7	*Sagittaria cuneata* Sheldon	arumleaf arrowhead
7	*Sagittaria latifolia* Willd.	broadleaf arrowhead
7	*Salicornia rubra* A. Nels.	red swampfire
7	*Salix amygdaloides* Anderss.	peachleaf willow
7	*Salix arctica* Pallas	arctic willow
8	*Salix barclayi* Anderss.	Barclay's willow

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10	*Salix barrattiana* Hook.	Barratt's willow
4	*Salix bebbiana* Sarg.	Bebb willow
6	*Salix boothii* Dorn	Booth's willow
6	*Salix brachycarpa* Nutt.	shortfruit willow
9	*Salix candida* Flueggé ex Willd.	sageleaf willow
7	*Salix commutata* Bebb	undergreen willow
5	*Salix drummondiana* Barratt ex Hook.	Drummond's willow
4	*Salix exigua* Nutt.	narrowleaf willow
7	*Salix farriae* Ball	Farr's willow
0	*Salix fragilis* L.	crack willow
6	*Salix geyeriana* Anderss.	Geyer's willow
7	*Salix glauca* L.	grayleaf willow
6	*Salix lemmonii* Bebb	Lemmon's willow
5	*Salix lucida* Muhl. ssp. *caudata* (Nutt.) E. Murr.	greenleaf willow
6	*Salix lutea* Nutt.	yellow willow
5	*Salix melanopsis* Nutt.	dusky willow
7	*Salix planifolia* Pursh	diamondleaf willow
7	*Salix prolixa* Anderss.	MacKenzie's willow
7	*Salix pseudomonticola* Ball	false mountain willow
4	*Salix scouleriana* Barratt ex Hook.	Scouler's willow
9	*Salix serissima* (Bailey) Fern.	autumn willow
8	*Salix sitchensis* Sanson ex Bong.	Sitka willow
7	*Salix tweedyi* (Bebb ex Rose) Ball	Tweedy's willow
7	*Salix vestita* Pursh	rock willow
7	*Salix wolfii* Bebb	Wolf's willow
6	*Saxifraga adscendens* L.	wedgeleaf saxifrage
6	*Saxifraga caespitosa* L.	tufted alpine saxifrage
8	*Saxifraga cernua* L.	nodding saxifrage
8	*Saxifraga ferruginea* Graham	russethair saxifrage
6	*Saxifraga integrifolia* Hook.	wholeleaf saxifrage
7	*Saxifraga lyallii* Engl.	redstem saxifrage
7	*Saxifraga mertensiana* Bong.	wood saxifrage
7	*Saxifraga nidifica* Greene	peak saxifrage
6	*Saxifraga occidentalis* S. Wats.	Alberta saxifrage
7	*Saxifraga odontoloma* Piper	brook saxifrage
6	*Saxifraga oregana* T.J. Howell	Oregon saxifrage
7	*Saxifraga rhomboidea* Greene	diamondleaf saxifrage
8	*Saxifraga rivularis* L.	weak saxifrage
10	*Scheuchzeria palustris* L.	rannoch-rush
5	*Schoenoplectus acutus* (Muhl. ex Bigelow) A.& D. Löve	hardstem bulrush
8	*Schoenoplectus heterochaetus* (Chase) Soják	slender bulrush
6	*Schoenoplectus maritimus* (L.) Lye	cosmopolitan bulrush
6	*Schoenoplectus pungens* (Vahl) Palla	common threesquare
9	*Schoenoplectus subterminalis* (Torr.) Soják	swaying bulrush
6	*Schoenoplectus tabernaemontani* (K.C. Gmel.) Palla	softstem bulrush
1	*Scirpus cyperinus* (L.) Kunth	woolgrass
5	*Scirpus microcarpus* J.& K. Presl	panicled bulrush
9	*Scirpus nevadensis* S. Wats.	Nevada bulrush
4	*Scrophularia lanceolata* Pursh	lanceleaf figwort

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6	*Scutellaria galericulata* L.	marsh skullcap
7	*Senecio crassulus* Gray	thickleaf ragwort
5	*Senecio hydrophiloides* Rydb.	tall groundwel
5	*Senecio hydrophilus* Nutt.	water ragwort
7	*Senecio integerrimus* Nutt.	lambstongue ragwort
5	*Senecio serra* Hook.	tall ragwort
6	*Senecio sphaerocephalus* Greene	ballhead ragwort
5	*Senecio triangularis* Hook.	arrowleaf ragwort
0	*Senecio vulgaris* L.	old-man-in-the-Spring
3	*Sidalcea oregana* (Nutt. ex Torr. & Gray) Gray	Oregon checkerbloom
6	*Silene menziesii* Hook.	Menzies' campion
6	*Silene uralensis* (Rupr.) Bocquet	apetalous catchfly
6	*Sisyrinchium idahoense* Bickn.	Idaho blue-eyed grass
6	*Sisyrinchium montanum* Greene	strict blue-eyed grass
8	*Sisyrinchium septentrionale* Bickn.	northern blue-eyed grass
7	*Sium suave* Walt.	hemlock waterparsnip
8	*Smilax lasioneura* Hook.	Blue Ridge carrionflower
1	*Solanum dulcamara* L.	climbing nightshade
3	*Solidago canadensis* L.	Canada goldenrod
6	*Solidago gigantea* Ait.	giant goldenrod
0	*Sonchus arvensis* L.	field sowthistle
0	*Sonchus asper* (L.) Hill	spiny sowthistle
7	*Sparganium angustifolium* Michx.	narrowleaf bur-reed
7	*Sparganium eurycarpum* Engelm. ex Gray	broadfruit bur-reed
6	*Sparganium natans* L.	small bur-reed
6	*Spartina gracilis* Trin.	alkali cordgrass
6	*Spartina pectinata* Bosc ex Link	prairie cordgrass
8	*Spergularia salina* J.& K. Presl	salt sandspurry
7	*Sphenopholis obtusata* (Michx.) Scribn.	prairie wedgescale
5	*Spiraea douglasii* Hook.	rose spirea
6	*Spiranthes romanzoffiana* Cham.	hooded ladies'-tresses
7	*Spirodela polyrrhiza* (L.) Schleid.	common duckmeat
7	*Sporobolus airoides* (Torr.) Torr.	alkali sacaton
6	*Stachys pilosa* Nutt.	hairy hedgenettle
6	*Stellaria borealis* Bigelow	boreal starwort
6	*Stellaria calycantha* (Ledeb.) Bong.	northern starwort
5	*Stellaria crassifolia* Ehrh.	fleshy starwort
4	*Stellaria crispa* Cham. & Schlecht.	curled starwort
6	*Stellaria longifolia* Muhl. ex Willd.	longleaf starwort
7	*Stellaria longipes* Goldie	longstalk starwort
7	*Stellaria umbellata* Turcz. ex Kar. & Kir.	umbrella starwort
7	*Stenanthium occidentale* Gray	western featherbells
7	*Streptopus amplexifolius* (L.) DC.	claspleaf twistedstalk
5	*Stuckenia pectinatus* (L.) Boerner	sago pondweed
3	*Suaeda calceoliformis* (Hook.) Moq.	Pursh seepweed
6	*Suaeda moquinii* (Torr.) Greene	Mojave seablite
7	*Suksdorfia ranunculifolia* (Hook.) Engl.	buttercup suksdorfia
8	*Suksdorfia violacea* Gray	violet suksdorfia
7	*Swertia perennis* L.	felwort

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3	*Symphoricarpos albus* (L.) Blake	common snowberry
4	*Symphoricarpos occidentalis* Hook.	western snowberry
2	*Symphyotrichum chilense* (Nees) Nesom	Pacific aster
5	*Symphyotrichum ciliatum* (Ledeb.) Nesom	rayless alkali aster
5	*Symphyotrichum eatonii* (Gray) Nesom	Eaton's aster
6	*Symphyotrichum ericoides* (L.) Nesom var. *pansum* (Blake) Nesom	manyflowered aster
5	*Symphyotrichum foliaceum* (DC.) Nesom	alpine leafybract aster
4	*Symphyotrichum frondosum* (Nutt.) Nesom	short-rayed alkalai aster
4	*Symphyotrichum lanceolatum* (Willd.) Nesom	white panicle aster
5	*Symphyotrichum spathulatum* (Lindl.) Nesom	western mountain aster
6	*Symphyotrichum subspicatum* (Nees) Nesom	Douglas aster
0	*Tamarix chinensis* Lour.	fivestamen tamarisk
0	*Taraxacum officinale* G.H. Weber ex Wiggers	common dandelion
9	*Thalictrum alpinum* L.	alpine meadow-rue
5	*Thalictrum dasycarpum* Fisch. & Avé-Lall.	purple meadow-rue
5	*Thalictrum occidentale* Gray	western meadow-rue
5	*Thalictrum sparsiflorum* Turcz. ex Fisch. & C.A. Mey.	fewflower meadow-rue
6	*Thermopsis montana* Nutt.	mountain goldenbanner
7	*Thuja plicata* Donn ex D. Don	western red cedar
7	*Tofieldia glutinosa* (Michx.) Pers.	sticky tofieldia
7	*Torreyochloa pallida* (Torr.) Church	pale false mannagrass
4	*Toxicodendron rydbergii* (Small ex Rydb.) Greene	western poison ivy
8	*Trautvetteria caroliniensis* (Walt.) Vail	Carolina bugbane
0	*Tribulus terrestris* L.	puncturevine
4	*Trifolium beckwithii* Brewer ex S. Wats.	Beckwith's clover
0	*Trifolium fragiferum* L.	strawberry clover
6	*Trifolium longipes* Nutt.	longstalk clover
1	*Trifolium microcephalum* Pursh	smallhead clover
7	*Trifolium parryi* Gray	Parry's clover
0	*Trifolium repens* L.	white clover
8	*Triglochin maritimum* L.	seaside arrowgrass
7	*Triglochin palustre* L.	marsh arrowgrass
1	*Triodanis perfoliata* (L.) Nieuwl.	clasping Venus' looking-glass
0	*Tripleurospermum perforata* (Merat) M. Lainz	scentless false mayweed
7	*Trollius laxus* Salisb.	American globeflower
7	*Typha angustifolia* L.	narrowleaf cattail
3	*Typha latifolia* L.	broadleaf cattail
3	*Urtica dioica* L.	stinging nettle
10	*Utricularia minor* L.	lesser bladderwort
8	*Vaccinium uliginosum* L.	bog blueberry
7	*Vahlodea atropurpurea* (Wahlenb.) Fries ex Hartman	mountain hairgrass
5	*Valeriana dioica* L.	marsh valerian
7	*Valeriana edulis* Nutt. ex Torr. & Gray	tobacco root
7	*Valeriana occidentalis* Heller	western valerian
7	*Valeriana sitchensis* Bong.	Sitka valerian
7	*Veratrum viride* Ait.	green false hellebore
5	*Veronica americana* Schwein. ex Benth.	American speedwell
4	*Veronica anagallis-aquatica* L.	water speedwell

C	Scientific Name	Common Name
7	*Veronica cusickii* Gray	Cusick's speedwell
4	*Veronica peregrina* L.	neckweed
6	*Veronica scutellata* L.	skullcap speedwell
2	*Veronica serpyllifolia* L.	thymeleaf speedwell
7	*Veronica wormskjoldii* Roemer & J.A. Schultes	American alpine speedwell
8	*Viburnum edule* (Michx.) Raf.	squashberry
5	*Viola adunca* Sm.	hookedspur violet
8	*Viola macloskeyi* Lloyd	small white violet
8	*Viola nephrophylla* Greene	northern bog violet
7	*Viola palustris* L.	marsh violet
8	*Viola renifolia* Gray	white violet
5	*Vitis riparia* Michx.	riverbank grape
7	*Wolffia brasiliensis* Weddell	Brazilian watermeal
7	*Wolffia columbiana* Karst.	Columbian watermeal
2	*Wyethia helianthoides* Nutt.	sunflower mule-ears
2	*Xanthium strumarium* L.	rough cockleburr
8	*Zannichellia palustris* L.	horned pondweed
5	*Zigadenus venenosus* S. Wats.	meadow deathcamas
6	*Zizania palustris* L.	northern wildrice
7	*Zizia aptera* (Gray) Fern.	meadow zizia

Appendix B. List and attributes of sampled plant species.

Appendix B. List and attributes of sampled plant species.

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Achillea millefolium L.	common yarrow	F	P	N	FACU	poor
Achnatherum nelsonii (Scribn.) Barkworth	Columbia needlegrass	G	P	N	UPL	n/a
Actaea rubra (Ait.) Willd.	red baneberry	F	P	N	UPL	poor
Agoseris glauca (Pursh) Raf.	pale agoseris	F	P	N	FAC	poor
Agrostis gigantea Roth	redtop	G	P	E	FAC	fair
Agrostis scabra Willd.	rough bentgrass	G	P	N	FAC	fair
Allium brevistylum S. Wats.	shortstyle onion	F	P	N	UPL	poor
Allium schoenoprasum L.	wild chives	F	P	N	FACW	poor
Alnus incana (L.) Moench	gray alder	S	P	N	FACW	good
Alopecurus aequalis Sobol.	shortawn foxtail	G	P	N	OBL	poor
Alopecurus alpinus Sm.	boreal alopecurus	G	P	N	FACW	fair
Alopecurus pratensis L.	meadow foxtail	G	P	E	FACW	fair
Androsace filiformis Retz.	filiform rockjasmine	F	A/B	N	FACW	poor
Angelica arguta Nutt.	Lyall's angelica	F	P	N	FACW	fair
Antennaria corymbosa E. Nels.	flat-top pussytoes	F	P	N	FAC	poor
Antennaria microphylla Rydb.	littleleaf pussytoes	F	P	N	UPL	poor
Argentina anserina (L.) Rydb.	silverweed cinquefoil	F	P	N	OBL	fair
Arnica mollis Hook.	hairy arnica	F	P	N	FAC	poor
Artemisia cana Pursh	silver sagebrush	S	P	N	FAC	fair
Artemisia frigida Willd.	prairie sagewort	S	P	N	UPL	n/a
Artemisia ludoviciana Nutt.	white sagebrush	S	P	N	FACU	n/a
Artemisia tridentata Nutt. ssp. *tridentata*	basin big sagebrush	S	P	N	FACU	poor
Artemisia tridentata Nutt. ssp. *vaseyana* (Rydb.) Beetle	mountain big sagebrush	S	P	N	UPL	n/a
Artemisia tridentata Nutt. ssp. *wyomingensis* Beetle & Young	Wyoming big sagebrush	S	P	N	UPL	n/a
Astragalus agrestis Dougl. ex G. Don	purple milkvetch	F	P	N	FACW	poor
Beckmannia syzigachne (Steud.) Fern.	American sloughgrass	G	A/B	N	OBL	fair
Bromus ciliatus L.	fringed brome	G	P	N	FAC	fair
Bromus marginatus Nees ex Steud.	mountain brome	G	P	N	UPL	n/a
Calamagrostis canadensis (Michx.) Beauv.	bluejoint	G	P	N	FACW	excellent
Calamagrostis stricta (Timm) Koel.	slimstem reedgrass	G	P	N	FACW	excellent
Campanula rotundifolia L.	bluebell bellflower	F	P	N	FACU	n/a
Canadanthus modestus (Lindl.) Nesom	giant mountain aster	F	P	N	FAC	poor

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Cardamine oligosperma Nutt.	little western bittercress	F	A/B	N	FACW	poor
Cardamine pensylvanica Muhl. ex Willd.	Pennsylvania bittercress	F	A/B	N	FACW	poor
Carex aquatilis Wahlenb.	water sedge	G	P	N	OBL	excellent
Carex aurea Nutt.	golden sedge	G	P	N	FACW	fair
Carex canescens L.	silvery sedge	G	P	N	FACW	good
Carex disperma Dewey	softleaf sedge	G	P	N	FACW	fair
Carex foenea Willd.	dryspike sedge	G	P	N	UPL	fair
Carex lenticularis Michx.	lakeshore sedge	G	P	N	FACW	good
Carex microptera Mackenzie	smallwing sedge	G	P	N	FAC	good
Carex nebrascensis Dewey	Nebraska sedge	G	P	N	OBL	excellent
Carex norvegica Retz.	Norway sedge	G	P	N	FACW	n/a
Carex pellita Muhl ex Willd.	woolly sedge	G	P	N	OBL	excellent
Carex praegracilis W. Boott	clustered field sedge	G	P	N	FACW	excellent
Carex praticola Rydb.	meadow sedge	G	P	N	FACW	n/a
Carex simulata Mackenzie	analogue sedge	G	P	N	OBL	excellent
Carex utriculata Boott	Northwest Territory sedge	G	P	N	OBL	excellent
Carex vesicaria L.	blister sedge	G	P	N	OBL	excellent
Carex L.	sedge	G	P	N	n/a	fair
Castilleja miniata Dougl. ex Hook.	giant red Indian paintbrush	F	P	N	FAC	poor
Catabrosa aquatica (L.) Beauv.	water whorlgrass	G	P	N	OBL	fair
Cerastium nutans Raf.	nodding chickweed	F	A/B	N	FACU	poor
Chamerion angustifolium (L.) Holub	fireweed	F	P	N	FACU	poor
Cirsium arvense (L.) Scop.	Canada thistle	F	P	E	FACU	fair
Cirsium scariosum Nutt.	meadow thistle	F	A/B	N	UPL	poor
Cirsium vulgare (Savi) Ten.	bull thistle	F	A/B	E	FACU	poor
Collomia linearis Nutt.	tiny trumpet	F	A/B	N	FACU	poor
Cynoglossum officinale L.	gypsyflower	F	A/B	E	FACU	poor
Danthonia intermedia Vasey	timber oatgrass	G	P	N	FACU	n/a
Dasiphora floribunda (Pursh) Kartesz, comb. nov. ined.	shrubby cinquefoil	S	P	N	FAC	fair
Deschampsia caespitosa (L.) Beauv.	tufted hairgrass	G	P	N	FACW	fair
Descurainia sophia (L.) Webb ex Prantl	herb sophia	F	A/B	E	UPL	n/a
Eleocharis palustris (L.) Roemer & J.A. Schultes	common spikerush	G	P	N	OBL	excellent
Eleocharis quinqueflora (F.X. Hartmann) Schwarz	fewflower spikerush	G	P	N	OBL	n/a

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Elymus repens (L.) Gould	quackgrass	G	P	E	FACU	excellent
Elymus trachycaulus (Link) Gould ex Shinners	slender wheatgrass	G	P	N	FAC	n/a
Epilobium anagallidifolium Lam.	pimpernel willowherb	F	P	N	FACW	poor
Epilobium ciliatum Raf.	fringed willowherb	F	P	N	FACW	poor
Epilobium palustre L.	marsh willowherb	F	P	N	OBL	poor
Equisetum arvense L.	field horsetail	F	P	N	FAC	good
Equisetum laevigatum A. Braun	smooth horsetail	F	P	N	FACW	fair
Ericameria nauseosa (Pallas ex Pursh) Nesom & Baird	rubber rabbitbrush	S	P	N	UPL	n/a
Erigeron gracilis Rydb.	quill fleabane	F	P	N	UPL	n/a
Erysimum cheiranthoides L.	wormseed wallflower	F	A/B	E	FACU	poor
Festuca idahoensis Elmer	Idaho fescue	G	P	N	FACU	n/a
Festuca rubra L.	red fescue	G	P	N	FAC	good
Fragaria virginiana Duchesne	Virginia strawberry	F	P	N	FACU	poor
Galium boreale L.	northern bedstraw	F	P	N	FACU	poor
Galium trifidum L.	threepetal bedstraw	F	P	N	FACW	poor
Galium triflorum Michx.	fragrant bedstraw	F	P	N	FACU	poor
Gentiana affinis Griseb.	pleated gentian	F	P	N	FACU	n/a
Geranium richardsonii Fisch. & Trautv.	Richardson's geranium	F	P	N	FAC	poor
Geranium viscosissimum Fisch. & C.A. Mey. ex C.A. Mey.	sticky purple geranium	F	P	N	FACU	poor
Geum macrophyllum Willd.	largeleaf avens	F	P	N	FACW	poor
Geum rivale L.	purple avens	F	P	N	FACW	n/a
Geum triflorum Pursh	old man's whiskers	F	P	N	FACU	n/a
Glyceria grandis S. Wats.	American mannagrass	G	P	N	OBL	fair
Glyceria striata (Lam.) A.S. Hitchc.	fowl mannagrass	G	P	N	OBL	fair
Heracleum maximum Bartr.	common cowparsnip	F	P	N	FAC	fair
Hordeum brachyantherum Nevski	meadow barley	G	P	N	FACW	fair
Hordeum jubatum L.	foxtail barley	G	P	N	FAC	poor
Iris missouriensis Nutt.	Rocky Mountain iris	F	P	N	FACW	fair
Juncus balticus Willd.	Baltic rush	G	P	N	OBL	excellent
Juncus ensifolius Wikstr.	swordleaf rush	G	P	N	FACW	poor
Juncus longistylis Torr.	longstyle rush	G	P	N	FACW	fair
Juncus mertensianus Bong.	Mertens' rush	G	P	N	OBL	fair
Juncus L.	rush	G	P	N	n/a	n/a

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Leymus cinereus (Scribn. & Merr.) A. Löve	basin wildrye	G	P	N	FAC	n/a
Ligusticum tenuifolium S. Wats.	Idaho licorice-root	F	P	N	FACW	poor
Lolium pratense (Huds.) S.J. Darbyshire	meadow ryegrass	G	P	E	FACU	n/a
Lupinus polyphyllus Lindl.	bigleaf lupine	F	P	N	FAC	poor
Lupinus sericeus Pursh	silky lupine	F	P	N	UPL	n/a
Luzula parviflora (Ehrh.) Desv.	smallflowered woodrush	G	P	N	FAC	poor
Lycopus asper Greene	rough bugleweed	F	P	N	OBL	poor
Maianthemum stellatum (L.) Link	starry false lily of the vally	F	P	N	FAC	poor
Mentha arvensis L.	wild mint	F	P	N	FACW	poor
Mertensia ciliata (James ex Torr.) G. Don	tall fringed bluebells	F	P	N	FACW	fair
Mimulus guttatus DC.	seep monkeyflower	F	A/B	N	OBL	poor
Moehringia lateriflora (L.) Fenzl	bluntleaf sandwort	F	P	N	FAC	poor
Montia chamissoi (Ledeb. ex Spreng.) Greene	water minerslettuce	F	P	N	OBL	poor
Muhlenbergia richardsonis (Trin.) Rydb.	mat muhly	G	P	N	FAC	poor
Osmorhiza berteroi DC.	sweetcicely	F	P	N	UPL	poor
Packera pseudaurea (Rydb.) W.A. Weber & A. Löve	falsegold groundsel	F	P	N	FACW	fair
Parnassia fimbriata Koenig	fringed grass of Parnassus	F	P	N	OBL	poor
Pascopyrum smithii (Rydb.) A. Löve	western wheatgrass	G	P	N	FACU	good
Pedicularis groenlandica Retz.	elephanthead lousewort	F	P	N	OBL	n/a
Penstemon procerus Dougl. ex Graham	littleflower penstemon	F	P	N	UPL	n/a
Phleum alpinum L.	alpine timothy	G	P	N	FAC	fair
Phleum pratense L.	timothy	G	P	N	FAC	fair
Picea engelmannii Parry ex Engelm.	Engelmann spruce	T	P	N	FAC	fair
Plantago major L.	common plantain	F	P	N	FAC	poor
Platanthera stricta Lindl.	slender bog orchid	F	P	N	FACW	poor
Poa arida Vasey	plains bluegrass	G	P	N	FAC	fair
Poa palustris L.	fowl bluegrass	G	P	E	FAC	fair
Poa pratensis L.	Kentucky bluegrass	G	P	E	FAC	poor
Poa secunda J. Presl	Sandberg bluegrass	G	P	N	FACU	n/a
Polemonium occidentale Greene	western polemonium	F	P	N	FACW	poor
Polygonum aviculare L.	prostrate knotweed	F	A/B	E	FACW	n/a
Polygonum douglasii Greene	Douglas' knotweed	F	A/B	N	FACU	n/a
Populus tremuloides Michx.	quaking aspen	T	P	N	FAC	good

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Potentilla gracilis Dougl. ex Hook.	slender cinquefoil	F	P	N	FAC	poor
Potentilla rivalis Nutt.	brook cinquefoil	F	A/B	N	FACW	poor
Pyrola asarifolia Michx.	liverleaf wintergreen	F	P	N	FACU	poor
Ranunculus abortivus L.	littleleaf buttercup	F	P	N	FACW	poor
Ranunculus acriformis Gray	sharpleaf buttercup	F	P	N	FACW	poor
Ranunculus aquatilis L.	whitewater crowfoot	F	P	N	OBL	poor
Ranunculus cymbalaria Pursh	alkali buttercup	F	P	N	OBL	poor
Ranunculus macounii Britt.	Macoun's buttercup	F	P	N	OBL	poor
Ranunculus L.	buttercup	F	P	N	n/a	poor
Rhus trilobata Nutt.	skunkbush sumac	S	P	N	UPL	good
Ribes L.	currant	S	P	N	FACU	good
Rosa woodsii Lindl.	Woods' rose	S	P	N	FAC	good
Rudbeckia occidentalis Nutt.	western coneflower	F	P	N	FACW	poor
Rumex aquaticus L.	western dock	F	P	N	FAC	fair
Rumex crispus L.	curly dock	F	P	E	FACW	fair
Salix bebbiana Sarg.	Bebb willow	S	P	N	FACW	excellent
Salix boothii Dorn	Booth's willow	S	P	N	FACW	excellent
Salix drummondiana Barratt ex Hook.	Drummond's willow	S	P	N	OBL	excellent
Salix exigua Nutt.	narrowleaf willow	S	P	N	OBL	excellent
Salix farriae Ball	Farr's willow	S	P	N	FACW	excellent
Salix geyeriana Anderss.	Geyer's willow	S	P	N	FACW	excellent
Salix lemmonii Bebb	Lemmon's willow	S	P	N	FACW	excellent
Salix lucida Muhl. ssp. *caudata* (Nutt.) E. Murr.	greenleaf willow	S	P	N	OBL	excellent
Salix planifolia Pursh	diamondleaf willow	S	P	N	FACW	n/a
Saxifraga oregana T.J. Howell	Oregon saxifrage	F	P	N	FACU	poor
Saxifraga L.	saxifrage	F	P	N	n/a	poor
Senecio hydrophiloides Rydb.	tall groundwel	F	P	N	FACW	fair
Senecio serra Hook.	tall ragwort	F	P	N	FACU	fair
Senecio sphaerocephalus Greene	ballhead ragwort	F	P	N	FACW	fair
Silene menziesii Hook.	Menzies' campion	F	P	N	FAC	poor
Sisyrinchium idahoense Bickn.	Idaho blue-eyed grass	F	P	N	FACW	poor
Sisyrinchium montanum Greene	strict blue-eyed grass	F	P	N	FACW	n/a
Solidago canadensis L.	Canada goldenrod	F	P	N	FACU	fair

Scientific Name	Common Name	Growth Form[a]	Duration[b]	Nativity[c]	Wetland Indicator Status[d]	Bank Stability Rating[e]
Stellaria crassifolia Ehrh.	fleshy starwort	F	P	N	FACW	poor
Stellaria longifolia Muhl. ex Willd.	longleaf starwort	F	P	N	FACW	poor
Stellaria L.	starwort	F	P	N	n/a	poor
Symphyotrichum foliaceum (DC.) Nesom	alpine leafybract aster	F	P	N	FACW	n/a
Symphyotrichum spathulatum (Lindl.) Nesom	western mountain aster	F	P	N	FAC	n/a
Symphyotrichum subspicatum (Nees) Nesom	Douglas aster	F	P	N	FACW	n/a
Symphyotrichum Nees	aster	F	P	N	n/a	poor
Taraxacum officinale G.H. Weber ex Wiggers	common dandelion	F	P	E	FACU	poor
Thalictrum occidentale Gray	western meadow-rue	F	P	N	FACU	poor
Thermopsis montana Nutt.	mountain goldenbanner	F	P	N	UPL	fair
Thlaspi arvense L.	field pennycress	F	A/B	E	UPL	poor
Tragopogon dubius Scop.	yellow salsify	F	A/B	E	UPL	n/a
Trifolium longipes Nutt.	longstalk clover	F	P	N	FAC	poor
Trifolium repens L.	white clover	F	A/B	E	FAC	poor
Triglochin palustre L.	marsh arrowgrass	F	P	N	OBL	poor
Urtica dioica L.	stinging nettle	F	P	N	FAC	fair
Veronica americana Schwein. ex Benth.	American speedwell	F	P	N	OBL	poor
Veronica serpyllifolia L.	thymeleaf speedwell	F	P	E	FAC	poor
Viola nephrophylla Greene	northern bog violet	F	P	N	FACU	poor
Viola L.	violet	F	P	N	n/a	poor

[a] F = forb/fern, G = graminoid, S = shrub, T = tree
[b] A/B = annual/biennial, P = perennial
[c] E = exotic, N = native
[d] OBL = obligate wetland, FACW = facultative wetland, FAC = facultative, FACU = facultative upland, UPL = obligate upland
[e] rating was calculated for species occurring in greenline samples only

APPENDIX C. LOCATION AND CONDITION RATING OF SAMPLE REACHES.

Appendix C. Location and condition rating of sample reaches.

Site Code	Stream	Location Latitude	Longitude	PFC Rating[a]	VIBI Score	VIBI Condition Class	Disturbance Score	Disturbance Category
CAMP	Camp Cr.	45.68156616	-112.56099008	FAR	0.60	moderately impaired	0.59	moderate
MORRISON	Morrison Cr.	44.70083328	-113.05396895	FAR	0.64	moderately impaired	0.80	most
NF_EVRSN	North Fork Everson Cr.	44.90777384	-113.33167515	PFC	0.75	reference	0.14	least
EF_BLACK	East Fork Blacktail Deer Cr.	44.84571892	-112.20396350	PFC	0.61	moderately impaired	0.36	moderate
WF_BLACK	West Fork Blacktail Deer Cr.	44.78252959	-112.31075800	NF	0.37	severely impaired	0.80	most
PRICE_DN	Middle Fork Price Cr.	44.57434567	-112.12498066	PFC	0.94	reference	0.04	least
L_BEAVER	Little Beaver Cr.	44.52808267	-112.47752761	FAR	0.59	moderately impaired	0.40	moderate
L_SHEEP	Little Sheep Cr.	44.58333903	-112.67295781	NF	0.47	severely impaired	0.53	moderate
L_SAGE	Little Sage Cr.	44.79545642	-112.52678974	FAR	0.47	severely impaired	0.77	most
MUDDY_TR	Tributary of Muddy Cr.	44.72151009	-112.89286223	NF	0.64	moderately impaired	0.71	moderate
MCNINCH	McNinch Cr.	44.69827957	-112.87387689	FAR	0.68	moderately impaired	0.40	moderate
NICHO_DN	Nicholia Cr.	44.54776607	-112.82693010	PFC	0.70	moderately impaired	0.73	moderate
TENDOY	Tendoy Cr.	44.45170686	-112.92159908	NF	0.53	moderately impaired	0.56	moderate
NICHO_UP	Nicholia Cr.	44.45793453	-112.91187976	PFC	0.54	moderately impaired	0.51	moderate
COW	Cow Cr.	44.65020038	-112.95523105	NF	0.68	moderately impaired	0.47	moderate
INDIAN	Indian Cr.	44.60515310	-113.00577929	PFC	0.76	reference	0.00	least
PRICE_UP	Middle Fork Price Cr.	44.56140133	-112.12400492	PFC	0.82	reference	0.30	least
L_SAGE_T	Tributary of Little Sage Cr.	44.81923495	-112.43812202	NF	0.54	moderately impaired	0.41	moderate
EAST	East Cr.	44.86921884	-112.54489046	NF	0.86	reference	0.28	least
BL_CANYN	Black Canyon Cr.	44.86336458	-113.32877526	PFC	0.80	reference	0.08	least
NF_DIVDE	North Fork Divide Cr.	44.81897227	-113.32126491	FAR	0.88	reference	0.52	moderate
HORSE_PR	Horse Prairie Cr.	44.81718742	-113.20700767	PFC	0.71	reference	0.19	least
SHENON	Shenon Cr.	44.92784061	-113.22862124	FAR	0.68	moderately impaired	0.67	moderate
RAPE	Rape Cr.	44.97097330	-113.21309485	NF	0.47	severely impaired	0.88	most
TAYLR_UP	Taylor Cr.	45.27322615	-112.98248908	NF	0.23	severely impaired	0.94	most
TAYLR_DN	Taylor Cr.	45.22943582	-112.99539160	PFC	0.50	moderately impaired	0.28	moderate
BLD_DICK	Bloody Dick Cr.	45.06979468	-113.42391657	PFC	0.96	reference	0.09	least
BG_HOLLW	Big Hollow Cr.	45.01306739	-113.35803380	FAR	0.34	severely impaired	1.00	most
SF_WAT_U	South Fork Watson Cr.	45.09592367	-113.19631118	NF	0.41	severely impaired	0.91	most
SF_WAT_D	South Fork Watson Cr.	45.07747150	-113.19649282	FAR	0.40	severely impaired	0.52	moderate

[a] FAR = functioning at risk, PFC = proper functioning condition, NF = nonfunctioning